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A STUDY OF STUDENT OPINION OF COLLEGE GENERAL EDUCATION SCIENCE COURSES

TRENDS AND PRESENT STATUS OF GENERALIZED SCIENCE IN STATE TEACHERS COLLEGES

RELATION OF BIOLOGICAL SCIENCE TO THE SOCIAL ATTITUDES

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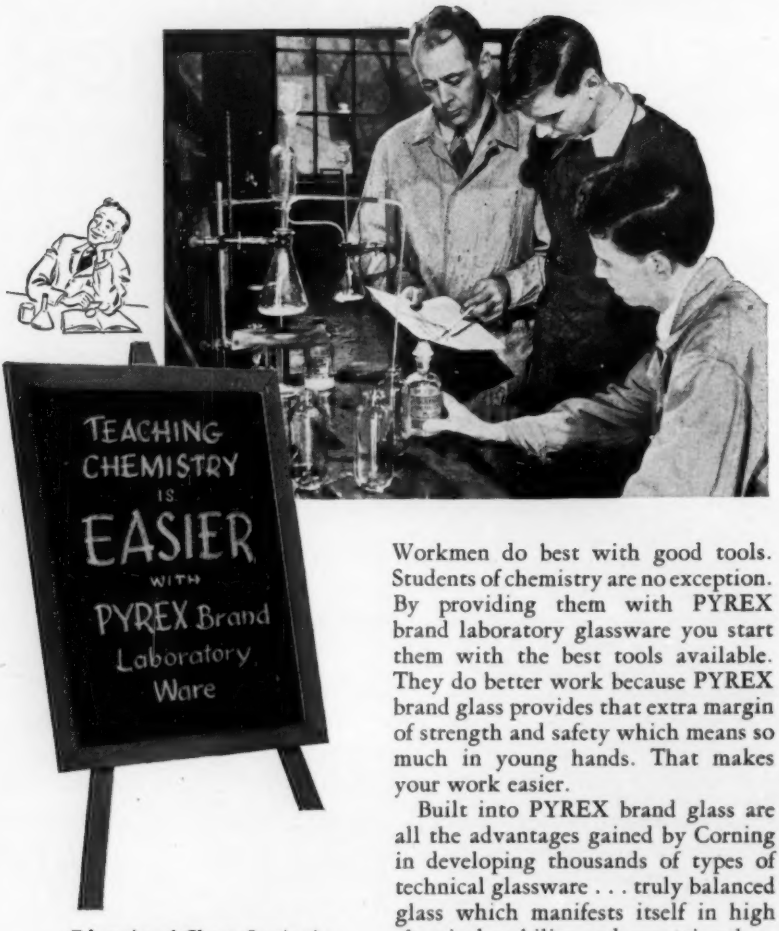

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SCIENCE EDUCATION

VOLUME 34 MARCH, 1950 NUMBER 2

A STUDY OF STUDENT OPINION OF COLLEGE GENERAL EDUCATION SCIENCE COURSES

ROBERT ADRIAN BULLINGTON

MacMurray College, Jacksonville, Illinois

IT is not unusual for a teacher to ask his students to appraise his course, but the results are seldom published.

In the spring of 1948, the writer had the opportunity to secure information from students in two different schools. The data gathered may be of interest to teachers engaged in presenting science to general students.

The purpose of this study is to evaluate, on the basis of student opinion, the instructional procedures used in two general education science courses and to ascertain the values of these courses to the students. The study has been undertaken with the assumption that student opinions and reactions are valid to use as criteria in judging the values of courses and the suitability of teaching procedures. This is especially true in cases of a general consensus of opinion.

Questionnaires were prepared and submitted to the students enrolled in two college science courses which have similar subject-matter content but which are presented by somewhat different procedures of instruction. Both courses are designed for the general student who does not plan to specialize in science. These courses are in different schools.

It is not the purpose of this study to attempt to show that one course is superior to the other, but rather to evaluate the procedures used in each on the basis of student answers to sets of questions.

Because of certain differences in the courses, the same identical questionnaire could not be used for both groups. Instead, two similar and comparable questionnaires were prepared, one to fit each situation. In the questionnaires, student reactions to various instructional procedures were sought. The study also covers student opinions as to the values of the courses to the students. That is, how well are the courses meeting the usual objectives of science courses designed for general education? The questions asked did not cover subject-matter content.

DESCRIPTION OF THE COURSES

Both of the courses are designed as general education courses for college freshmen with liberal arts programs. Each course includes a semester or quarter of study of material from the physical sciences followed by a similar period devoted to a study of content from the biological sciences.

The following statement concerning these courses were true in the spring of 1948 at the time the questionnaires were submitted. Some modifications have been made in each course for the fall of 1948.

Course A: A course enrollment of 160 students is divided into five sections which meet independently. Only one instructor meets a given section during the entire year. The classes meet four hours each week. Credit is four hours for each of the semesters.

Instruction is by a combination of lectures, demonstrations, and discussions combined in proportions suitable to the subject matter being covered. There is no laboratory with student participation.

Audio-visual teaching aids such as motion pictures and slides are freely used.

Carefully selected motion pictures are used about once a week. A micro-projector and opaque projector are available for use with appropriate materials.[1]

Course B: This course has an enrollment of 130 students. Credit is four hours for each of two quarters. The students meet in one group for lectures three times a week. They are divided into groups of about twenty each for two quiz-discussion periods per week. They are divided into groups of about fifteen for a two-hour laboratory meeting on alternate weeks. This gives an average of six hours in class a week.

The lectures are presented by a number of subject-matter specialists from the various departments of science. There were six different lecturers presenting the physical sciences during the first quarter. Another group of four lecturers from the biological sciences presented the lectures during the spring quarter, aided by three of the winter lecturers, who gave one or two lectures each.

An individual student meets one of these lecturers as a leader of a discussion group. The student has a laboratory instructor who does not give any of the lectures or conduct any discussion sections. Thus, during this course, a student has contact with eleven or twelve faculty personalities.

The lectures are frequently illustrated with demonstrations, charts, models, and slides. Motion pictures are rarely used.

[1] For a description of the audio-visual materials used in the course, see the author's article, "Audio-Visual Aids in College Science," *Science Education*, Vol. 32, No. 1, February, 1948.

EVALUATION OF THE COURSES

Little information is available concerning the evaluation of any phase of the generalized type of science course that is designed for non-science students. A survey of the literature of the last decade reveals an occasional attempt to measure retention of subject-matter, acquisition of scientific attitudes, or the relative values of laboratory exercises versus demonstration. Some studies have been made to determine subject-matter content.

To the writer's knowledge, little has been published concerning evaluation of methods of instruction through student opinion. Therefore, the results reported here are presented with the belief that they will be of value to teachers concerned with general courses.

There are certain limitations in the data. Some students were probably influenced by comments of their colleagues. Some may have hesitated to register their real opinion. In a few cases students made criticisms that were completely untrue. However, it is felt that the data is quite valid.

To simplify the discussion of the results, the items covered in the questionnaires have been divided into several categories. Each will now be considered in turn. The significant statistical results are included in Table I.

TABLE I

SUMMARY OF STUDENT OPINION OF COURSES AND PROCEDURES SHOWING PERCENTAGE OF STUDENTS ANSWERING *YES*

	Course A	Course B
1. Would like course extended to two years	49.7	45.5
2. Would like Course B extended from two to three quarters		71.9
3. Would like Course A to include a weekly discussion period	62.7	
4. Would like Course A to include laboratory work	60.4	
5. In general, like teacher system in use	82.7	91.2
6. Prefer present teacher system to others suggested	62.1	89.4
7. Have enjoyed the course	92.1	75.7
8. Would recommend the course to others	91.5	70.0
9. Have disliked the course	7.1	19.0
10. Wish they had not taken course	6.1	18.0
11. Think the course has been of value	93.5	74.6
12. Would recommend use of same or more demonstrations	98.7	97.3
13. Would recommend use of same or more projected still pictures	72.8	80.1
14. Would recommend use of same or more motion pictures	94.7	94.6

1. *Length of Course.* Opinions concerning the length of a course are largely reflections of interest and of realization of the values of the course. Nearly 72 per cent of the students in Course B would like to have the course extended from two to three quarters. Approximately 50 per cent of the students in each course would like the time extended to two years. Many students believe that the courses are too short to adequately cover the scientific material which is important for the general student. The writer recommends that schools which now offer or require only one year of science for the general student give serious consideration to a two-year requirement.

2. *Teacher System.* It is evident that regardless of the system used, the students prefer the system to which they are accustomed, even though they may be critical of some phases of it. Of the Course A students, 82.7 per cent like the single-teacher system, with 62.1 per cent definitely choosing it in preference to the multiple-teacher system. Of the Course B students, 91.2 per cent give general approval of the multiple system, with 89.4 per cent preferring it to the single system.

Although students prefer the *status quo,* the statistics are in favor of the multiple-teacher system. However, this system was criticized by a number of students, chiefly on the basis of dislike of one or more of the lecturers. Students offered little specific criticism of the single-teacher system.

It is evident that the more complicated the system of instruction, the greater the number of problems. The variety of personalities that a student meets in the multiple-teacher system is definitely interesting and stimulating to the student, in spite of the fact that the student may not like certain individuals.

No one teacher, however excellent, is likely to please every student. It is unfortunate if a student must meet for a whole year with an instructor he does not like. This places a strong obligation upon the teacher to do his best work, so that he will have the approval of as many of his students as possible.

We cannot conclude that one system is superior to the other. Each has its advantages and disadvantages. In general, the multiple system gives more expert instruction in each of the sciences and offers variety to the course. The single system is simpler and more economical to administer and creates fewer problems. The big difficulty is in finding teachers not only qualified to teach a variety of sciences but also willing to assume the responsibility of doing so.

3. *Demonstrations.* Demonstrations with the lectures are used extensively in both courses and are very popular with the students. A total of only five students would either reduce or omit demonstrations. An increase in the number of demonstrations was favored by 84.2 per cent of one group and by 58.6 per cent of the other group of students. Of the things that were liked, demonstrations were given top rating in both schools.

4. *Audio-Visual Aids.* Students like the use of projected materials, especially motion pictures. Only about five per cent in each course would reduce or eliminate the use of motion pictures. Their popularity in Course A is attested by the 78.1 per cent who would have more than the present average of one film per week. Over 88 per cent of Course B students would like to have more than the single picture they had seen.

Slides and film strips are less popular. About one-fourth of the students would reduce or omit their use. However, this is a smaller group than that which would increase the use of them.

The use of projected still pictures is fully justified. Possibly instructors should give more careful attention to selection of the pictures.

5. *Laboratory.* The question of the inclusion of laboratory work in a general course has been discussed at great length by science teachers. From the students' standpoint laboratory work seems justi-

fied. The laboratory was one of the most frequently mentioned items liked by Course B students. Nearly 80 per cent would like the same or more laboratory time. In Course A, where laboratory work does not now exist, 60.4 per cent of the students think it should be introduced.

However, there are objectors to the laboratory in Course B. Nine per cent would reduce the laboratory time; 15 per cent would omit it entirely. In the free comments, 11 students stated objections to the laboratory. Most of these thought that it was too easy or a waste of time. It is quite possible that these students have had extensive laboratory experience in high school, and are merely repeating former activities in the experiments assigned.

From contact with students in the laboratory, the writer knows that students with no previous laboratory experience derive a great deal of pleasure and benefit from their direct contact with science materials.

Through several aspects of this study we find the recurring need for a consideration of individual differences in scientific background. In the laboratory this might be done by excusing advanced students from laboratory work and assigning them papers or projects instead. Another suggestion is to have a laboratory program of two levels of difficulty, and segregate the students on the basis of previous experience.

6. *Quiz-Discussion Period.* Students give general approval to periods set aside for quizzes and student discussion. In Course A, where all discussion is integrated with the lectures, 62.7 per cent of the students would favor the introduction of a period designed especially for discussion.

In Course B, 63.2 per cent approve the present two hours per week, 15.8 per cent would increase it, and 19.3 per cent would reduce it.

If lecture groups are small, as in Course A, student discussion may well be encouraged during the lecture periods. The success of this plan rests largely with the teacher. If lecture groups are large, smaller discussion groups seem necessary so that students may ask about things not understood from the lectures. In either case, the students should have the opportunity to ask questions and to discuss the course material with an instructor.

7. *Subject-Matter Content.* This category was not included in the questionnaire, but the comments of the students reveal certain things. Some students prefer the physical sciences; some, the biological sciences. The women expressed strong preference for the biological sciences or certain topics therefrom.

Some students in both courses considered the course content too difficult; others considered it too easy. This again brings up the question of differences in the background and the ability of students. There is no easy solution to the problem of selection of content.

8. *General Opinion.* An unpopular required course may survive with adequate enrollment longer than an elective course. The latter type must stand on its merits. The instructors must make every effort to improve the course so that it will be well-liked. The students will derive more lasting benefit from the course that is a happy experience.

It is gratifying that a large percentage of both groups of students like the course they are taking. This is even surprising if one considers the fact that not one of these students is a science major. All are taking science as a part of their general education requirements. The general science course that meets the approval of a large majority of students has won an important place in the college curriculum of today.

Listed below are the most frequently mentioned items in the free-will comments of students. These are summarized from questions asking what the student particularly *likes* about the course and what he *dislikes*. The items are given in order of frequency of mention.

WHAT THE STUDENTS LIKE

Demonstrations with lectures
The laboratory
Comprehensive coverage of science
Opportunity for student discussion
Certain topics or lectures
A variety of lecturers
Relationship of course to everyday life
Use of audio-visual aids

WHAT THE STUDENTS DISLIKE

Certain lectures or certain topics
Too much material covered or time too short
Too difficult or too technical
Laboratory work
Course too general
Course too easy
Supplementary reading assignments
The text used.

SUMMARY

On the basis of factors emphasized in this survey of student opinion, the writer would like to offer some suggestions as a guide for interested persons to use in planning a science course for the general student. No specific recommendation of objectives or course content will be made.

The first step in planning a course is the selection by the teaching staff of the objectives to be achieved by instruction. At an early meeting of the students in the course the chosen objectives are explained and frequent reference is made to them during the course.

The selection of course content is important. Whatever it is, it is chosen with consideration for the objectives of the course and the specific needs of the students. More important than actual content is effective presentation that will lead to an understanding of science and a development of acceptable attitudes.

The "ideal" course extends at least through one school year. In most situations a two-year program in science is desirable for the general student. A course may be administered either by one broadly-trained teacher or by a small group of subject-matter specialists who understand the viewpoints and needs of general students. Instruction is principally by the lecture-demonstration method, supplemented by laboratory exercises (at least for the students with no previous laboratory experience). Audio-visual aids, especially motion pictures, are used regularly. Careful attention is given to the selection of the materials and their integration with the subject-matter content. Discussion and laboratory groups are small. Students are given ample opportunity to ask questions and to discuss the subject under consideration, either during lecture periods or in special discussion meetings.

No course can be ideal for all situations. Those interested in developing a general education program in science must carefully consider the local needs and borrow that which is appropriate from the experience of others.

TRENDS AND PRESENT STATUS OF GENERALIZED SCIENCE IN STATE TEACHERS COLLEGES

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INTRODUCTION

IN 1938 an unpublished study [1] was completed by the writer on the development of generalized science courses in state teachers colleges. It is the purpose of this investigation to bring the findings of that study up to date, showing the present status, trends, and general development in this field for the ten-year period from 1938 through the school year 1948–49.

For the purposes of this study a definition of generalized science similar to that

[1] Reynolds, Charles W., *The Development of Generalized Science Courses in State Teachers Colleges.* George Peabody College for Teachers, Nashville, Tennessee, 1938.

used by Havighurst[2] for survey courses will be adopted: A generalized science course is any course intended for college students which draws its subject matter from two or more of the different science divisions such as astronomy, chemistry, physics, et cetera.

SOURCE OF DATA

Data for the previous study were obtained, in part, from a questionnaire sent by the writer to all of the four-year state teachers colleges. Junior colleges, normal schools, and educational divisions of state universities were not included. Replies were received from 118, or 89 per cent of the total number of teachers colleges.

In order to obtain comparable data, the same questionnaire was employed in contacting these schools in the spring of 1949. Replies were received from 79, or 60 per cent of the total number of teachers colleges. Since the returns were well distributed over the country, the sampling is believed to be sufficient to show significant trends and the general status of these courses at the present time.

SCOPE OF GENERALIZED SCIENCE

In 1938 the total enrollment in survey science for 64 reporting schools was 8,542 or an average of 135 per school. The number taking these courses varied from 6 in one school to 671 in another.

At present 55 schools report a total enrollment of 12,355 in generalized science. This gives an average of 225 per school. Since the over-all enrollments in teachers colleges for the post war years have not increased materially over the pre-war period, the increase in the enrollments in generalized science seems to be significant.

In answer to the question, "Is generalized science a required subject?" 85 per cent report, "yes" (under varying conditions). In 1938 only 78 per cent of the schools made similar requirements. The most significant change noted in the survey science requirement is in the case of students majoring in elementary education. The number of schools requiring this type course for elementary majors increased from 11 per cent of the total number of colleges having a general science requirement in 1938, to 20 per cent in 1949.

MATERIALS

The instructors of generalized science seem to be better satisfied with available textbooks for these courses. This is evidenced by the fact that in 1938 fourteen colleges had no basic text, while the recent returns show only one school reporting no basic text. The diversity of opinion as to just what subject matter should be emphasized is still apparent from the widely scattered selection of different texts.

The textbooks now reported in use by four or more colleges are as follows:

The Physical Sciences by Cable, Getchell, and Kadesch	8
Science for the Elementary School Teacher by Craig	8
Fundamentals of Science by Krauskopf	7
Man and the Nature of His Physical Universe by Jean, Harrah, Herman, and Powers	5
Man and the Nature of His Biological World by Jean and Others	5
Man's Physical Universe by Bawden	4
Man and His Physical World by Gray	4

Three of these books were reported in use in 1938, namely, the two written by Jean and others and the one by Bawden. Many of the texts listed are merely introductory books for general courses in the older subject matter fields. This is especially true in the biological field.

Another indication that generalized science textbooks are meeting the felt needs of the science instructors is the distinct change from syllabi to texts. Only two colleges report the use of a syllabus at this time; whereas, the 1938 investigation listed twenty-one.

A generalized science course introduces the student to a wide variety of scientific apparatus and materials. Instead of being confined to certain equipment pertaining to a definite subject matter as in the case

[2] Havighurst, Robert J. "Survey Courses in the Natural Sciences." *The American Physics Teacher*, 1935, 3:97–101.

of physics or chemistry, the survey courses include laboratory equipment and demonstrations involving the equipment of many of these specific fields. Also, a great amount of material not found in technical laboratories is used in these courses.

Supplementary materials used in connection with generalized science instruction, as shown by the questionnaire returns are as follows: apparatus for general physics, general chemistry, and general biology; rocks, minerals, fossils, pictures, industrial specimens, slides, object materials, maps, models, silent films, plant and animal collections, and sound films.

The general physics apparatus is listed as being used most frequently. The questionnaire returns show a distinct decrease in the use of industrial specimens. This could be due, partially, to war shortages in these materials. It is interesting to note that silent films are still listed as being used by more colleges than the sound films.

ENROLLMENT BY SCHOLASTIC LEVEL

The enrollment in generalized science seems to be made up of approximately 60 per cent freshmen, 35 per cent sophomores, and the remaining 5 per cent of juniors and seniors. However, one school showed the enrollment in these courses to be composed entirely of juniors. The general practice seems to be that of giving generalized science as a required course for only freshmen and sophomores. This probably accounts for the large enrollment at that level.

SUBJECT MATTER PRESENTED

There is a wide variation in the total time allotted to generalized science in the different institutions. Many schools do not include biological science in their survey. Courses in general biology or nature study are given instead. When biological sciences are included in the survey program, two separate courses are usually given, one in the physical sciences and one in the biological sciences.

The physical science course contains approximately 40 per cent physics; 20 per cent each of chemistry, astronomy, and earth sciences. However, other sciences such as photography are frequently given some attention.

During the ten-year period under study, this subject-matter proportionment has changed very little.

METHODS OF INSTRUCTION

There has been a great diversity of opinion as to the proper method of presenting these courses. The early orientation courses were mere lectures given to incoming freshmen for the purpose of introducing them to college life. As these courses developed they became more of the introductory type. Although the teachers were mostly subject-matter specialists in areas of subject matter where the lecture and individual laboratory procedures were well established, various procedures were tried in the presentation of this new endeavor.

The 1938 study revealed that 47 per cent of class time was devoted to the lecture method, 41 per cent to lecture-demonstration, 10 per cent to individual laboratory, and 8 per cent to student-demonstration.

The present investigation shows quite a change in instructional procedures. The reporting schools now employ the lecture method 56 per cent of the time. The lecture-demonstration method is used 23 per cent of the time, individual laboratory work is allotted 14 per cent of the time, while only three per cent of instructional work is of the student-demonstration type.

In spite of the increased enrollment in generalized science courses there is a distinct increase in the per cent of time devoted to individual laboratory instruction. The returns also show a great decrease in the amount of time taken up by demonstrations, especially student demonstrations. This is to be expected, however, in view of the increased use of individual laboratory instruction.

SUMMARY

1. There has been a significant increase in the enrollments in generalized science during the past ten years as compared to

the over-all enrollment in teachers colleges.

2. There is a trend toward requiring these courses to satisfy the requirement for general education, or for some specific curricula. This trend is especially evident in the case of students majoring in elementary education.

3. There is a definite shift from syllabi, outlines, et cetera, to a basic text.

4. More of the teachers colleges use silent films than sound films.

5. The general practice seems to be that of requiring generalized science at the freshman and sophomore levels.

6. Generalized science is usually presented as two separate courses; one in the biological sciences, and one in the physical sciences.

7. As to methods of instruction, there is evidence of a general trend toward the procedures of the older, traditional sciences, that of lecture and individual laboratory.

It is not the purpose of this paper to formulate subjective evaluations or to make predictions, but to present the data obtained in order to give the reader a picture of the conditions as they exist from which he may make his own deductions.

RELATION OF BIOLOGICAL SCIENCE TO THE SOCIAL ATTITUDES *

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DURING the organization of the Basic College at Michigan State College the members of the Department of Biological Science included the following among their objectives: the developing of freedom from superstition, intolerance, and prejudice. One way to develop this objective is stressing the method of science. John Dewey [1] stated that ". . . the responsibility of science cannot be fulfilled by methods that are chiefly concerned with self-perpetuation of specialized science to the neglect of influencing the much larger number to adopt into the very make up of their minds those attitudes of openmindedness, intellectual integrity, observation, and interest in testing their opinions and beliefs, that are characteristic of the scientific attitude." Upon study of this statement one may see that the social attitudes that are recognized as "good" in a democracy stem from the very attributes that Dewey assigns to the scientific attitude. That is, it is hoped that the teaching and the development of the scientific attitude until it becomes a part of the very make up of the student will lead to the development of democratic individuals.

In transferring the scientific attitude from the laboratory to the everyday life of the student Lawson [2] has stated the procedure in use in the Department of Biological Science at Michigan State College as: "The scientific method is useful in arriving at opinions that guide the course of action. In terms of the scientific method the opinion is the hypothesis, and a person trained in this method will be aware of the basis (facts) on which the opinion (hypothesis) has been made. His degree of confidence in the opinion will vary according to the adequacy of the facts used in its formulation. An opinion based on many verified facts will be given more weight than one without substantiation. When an opinion has been accepted it will not be accepted unconditionally, but further information will be sought in order to revaluate it. In terms of the scientific method the hypothesis (opinion) will be

* Contribution No. 25 from the Department of Biological Science, Michigan State College.

tested. If this further information supports the original opinion more confidence can be placed in it. However, if it disagrees with the opinion all of the information must be re-examined in order to formulate a new one. A new hypothesis is made to fit all of the facts."

The study of the races of man during the last of the three quarters of Biological Science afforded an opportunity to apply the scientific method to the problem of racial, religious, and national prejudice. The result of a pilot study led the authors to conduct the following study to determine whether or not any significant change in the attitude of the student in regard to these prejudices has taken place after he has been exposed to the program in the Department of Biological Science.

METHOD

The classroom methods for the accomplishment of these goals, the characteristics of the scientific attitude, were discussed at the several weekly staff meetings preceding the study of this area. These meetings were for the purpose of gaining an uniform understanding of the specific objectives to be accomplished. Uniformity was also aided in that the same laboratory manual [3] was used in all sections. The following points were brought out during the staff discussions: (1) "race" is a difficult term for even trained biologists to define, (2) the characteristics by which biologists classify races of man are only norms, and there is no guarantee that all of the individuals will fall near the median point of the curve, (3) the means by which the layman classified the races of man are most inadequate and superficial, and (4) there are relatively few individuals in the United States who will fall into definite subdivisions of the Caucasian race to the exclusion of the other subdivisions.

Students were given a questionnaire which was a duplicate of Table I in this paper and asked to place a "+" in the appropriate space if they felt that the students in the indicated group should be permitted to engage in the activity, or a "—" if they would rather have them excluded from that activity. In tabulating the results all space left blank by the students were counted as a "—" as it is believed that if they were undecided they should not be counted as free from prejudice.

All three terms of biological science are taught simultaneously each 12-week term, with the study of the races of man being placed near the end of the last quarter. It was therefore decided that the questionnaire would be given to students in all three quarters simultaneously, but after the third quarter students had finished their study of racial biology. The questionnaire was given at a time when the largest enrollment was in the third term, and the first and second term students were combined as the control. The questionnaire was administered by the students' regular laboratory instructor at the laboratory class meeting during the specified week. The instructors were asked not to make any comments other than to ask the student to read the directions on the questionnaire and to comply with them.

In determining significant differences between the units of the control groups (as shown in Table I) and between the control and experimental groups (as shown in Table II) the following formula was used:

$$\text{Ratio } t = \frac{Ps - Pu}{\sqrt{Pq\left(\frac{1}{N_s} + \frac{1}{N_u}\right)}}$$

$$\text{Where } P = \frac{(Ns \cdot Ps) + (Nu \cdot Pu)}{Ns + Nu}$$

$$\text{Where } q = 1 - p$$

Where:

Ps = % "no" in the control group
Pu = % "no" in the experimental group
Ns = Total number of "no" in the control group
Nu = Total number of "no" in the experimental group

If "t" ratio, disregarding the sign, is greater than 1.96 it is a significant difference. If "t" ratio is greater than 2.58 it is a highly significant difference.

The control used in this study may be

questioned because of the practice of permitting some students to write the comprehensive examination at the end of the first or second quarter of study. Those who pass the examination are excused from enrolling in the remaining courses in the series. It is assumed that these students are the more capable among the student body because of the requirement that they have above average grades in order to be given this privilege. As a consequence there is a loss of the better students from the first course and also from the second course. This would seemingly give us unequated control and experimental groups. We might assume that the better students are less prejudiced. This seems to be borne out by a study of Table I. Table I compares the first quarter students with second quarter students. Neither group had studied racial biology so far as this course is concerned. The essential difference is that the second quarter students are a partially selected group due to elimination of those better-than-average students who took the comprehensive

TABLE I

COMPARING FIRST QUARTER AND SECOND QUARTER STUDENTS IN BASIC BIOLOGICAL SCIENCE AS TO PERCENTAGE PREJUDICE AND SIGNIFICANT DIFFERENCE

	Chinese	German	Italian	Japanese	Mexican	Negro	Jew	Catholic	Protestant
Should be allowed to come to this school	000 001 *	007 013	010 013	017 063 **	017 039 *	024 028	019 025	002 003	000 000
Hold office of student council pres.	074 096	048 074	050 083	126 188 **	107 142	110 145	086 090	005 007	000 001
Be editor of school newspaper	057 095	045 076	043 084 *	119 185 **	086 131 *	095 136 *	074 083	005 009	001 000
Play on football team	014 015	005 009	005 007	031 047	017 030	017 025	017 018	000 003	000 000
Be a member of track team	007 013	008 009	005 009	021 045 *	017 025	014 019	014 015	000 003	000 000
Attend school parties	019 030	007 013	010 015	043 071	052 062	102 113	019 022	000 004	000 000
Dance with students not of his own group	150 179 **	014 030	040 051	205 276 **	230 267	543 602 *	050 065	007 016	007 012
Be given a scholarship	012 021	019 028	019 028	038 077 **	021 047 *	021 028	017 033	002 004	000 000
Belong to school clubs	007 018	012 013	010 016	033 057	033 043	050 043	026 027	002 002	002 000
Use school swimming pool	014 036 *	012 012	017 025	043 086 **	062 087	138 154	021 031	002 006	000 001
Be invited to your home	069 089	019 034	036 063 *	148 195 *	183 212	360 396	102 115	010 013	002 006
Be invited to work on a committee	005 018	012 016	014 021	026 068	021 042	003 054 **	026 027	000 003	000 001

The upper number in each space shows the percentage of students in the first quarter of Basic Biological Science marking the space with a "—"; the lower number shows the percentage of students in the second quarter of the course marking that space with a "—". If an asterisk is present in the space the difference is significant. If two asterisks appear in the space the difference is highly significant.

examination early. While many of the differences are not statistically significant, it is interesting to note that the first quarter students show less prejudice than the partially selected second quarter students. This may be due to the selection process.

It is believed that a control of this type is the best available because it eliminates the change of attitudes due to current events, an effect which might be severely felt if the same students were questioned before and after the study of racial biology. The number of students is large enough so that both the control and the experimental group are adequate samples.

DATA

The control was composed of 1091 students, the experimental group had 1334 students surveyed. In the control, 32.5 per cent of the students had all "+" answers; among the third quarter students 41.7 per cent of the papers were all "+". This gives a ratio t of 4.8, or a highly significant difference. It will be noted in

TABLE II

COMPARING CONTROL AND EXPERIMENTAL GROUPS AS TO PERCENTAGE PREJUDICE AND SIGNIFICANT DIFFERENCES

	Chinese	German	Italian	Japanese	Mexican	Negro	Jew	Catholic	Protestant
Should be allowed to come to this school	001	011	012	046	030	027	023	003	000
	003	003	004	020	014	011	019	000	000
		**	*	**	**			*	
Hold office of student council pres.	088	064	071	164	128	131	089	006	001
	050	014	023	095	066	085	038	006	000
	**	**	**	**	**	**	**		
Be editor of school newspaper	081	062	069	159	114	120	080	007	001
	056	021	025	090	062	076	050	007	000
	*	**	**	**	**	**	**		
Play on football team	015	007	006	041	025	022	017	022	000
	006	002	004	015	013	007	017	000	000
	*	*		**	*	*			
Be a member of track team	011	007	007	037	022	017	015	002	000
	003	001	005	015	008	006	015	000	003
	**	**		**	**	**			
Attend school parties	026	011	013	055	059	109	021	003	000
	012	003	008	030	037	059	019	000	000
		**				**		*	
Dance with students not of his own group	168	024	048	248	254	579	060	013	010
	130	017	024	164	172	485	050	010	009
	**		**	**	**	**	**		
Be given a scholarship	017	025	025	062	038	066	027	004	000
	010	008	008	029	015	010	019	000	000
		**	**	**	**	**		**	
Belong to school clubs	014	013	014	049	039	046	027	003	001
	004	003	005	021	019	023	022	000	000
	**	**	*	**	**	**		*	
Use school swimming pool	027	012	022	070	078	148	027	005	001
	014	004	008	028	044	075	025	000	000
	*	*	**	**	**	**		**	
Be invited to your home	082	028	053	177	201	382	110	012	005
	041	007	018	088	119	304	062	000	000
	**	**	**	**	**	**	**	**	
Be invited to work on a committee	013	015	018	052	034	047	024	002	001
	006	003	009	020	010	021	018	000	000
		**	*	**	**	**			

The upper number in each space shows the percentage of students in the control group marking that space with a "—"; the lower number shows the percentage of students in the experimental group marking that space with a "—". If an asterisk is present in the space the difference is significant. If two asterisks appear in a space the difference is highly significant.

Table II that the greatest amount of disapproval was found in regard to Negro students dancing with non-Negro students. Dancing was also the subject of the greatest amount of disapproval by the control group with regard to the Chinese, Mexicans, Catholics and Protestants, although in the latter two instances there was less than 1.5 per cent negative answers. Other categories showing a high percentage of negative responses are: inviting persons of other groups to one's home; electing a student council president; and appointing an editor of the school newspaper from among the other groups. The greater numerical decreases were found in these same categories. The greatest decrease was found in the category showing the greatest amount of objection, that of the Negro student dancing with the non-Negro student.

A study of Table II will show that sixty of the one hundred and eight categories listed showed a drop that was highly significant. Sixteen of these categories showed a significant drop in prejudice. Thirty-two categories showed no significant change. Of these thirty-two categories, twenty-five showed less than 2 per cent negative response. In the case of the Negro there was a highly significant drop in every case. In the case of the Mexican there was a highly significant drop in every category except one.

A further study of Table II may reveal some general underlying principles of prejudice insofar as the scope of this study permits. It would appear that if any such principles exist they might be (1) objection to physical contact with persons of other groups, and (2) objection to placing persons of other groups in a position where they can strongly influence student thought or activities. The first principle is illustrated by the relatively great objection to dancing and to inviting persons to one's home; and the relatively little objection to having them play on collegiate teams where the contact with the main student body would be at a minimum. The second principle is brought out by the relatively great objection to having a person of another group as student council president, or as editor of the school paper, together with the slight objection to having them attend school parties and belong to school clubs where any influence that they might have could be easily counterbalanced.

SUMMARY

A survey was made as to racial, religious and national prejudices of students enrolled in Basic Biological Science in Michigan State College. The survey was made to determine whether or not the application of the scientific method to the study of racial biology would in any way alter the above social prejudices of the students taking the course. The data seem to indicate that the teaching of the biology of the races of man with the intent of applying the scientific method of thought to the problem of racial, religious and national prejudice does have a beneficial effect. The study brought out two underlying types of prejudice: (1) the objection to physical contact with persons of other groups, and (2) the objection to placing persons of other groups in positions where they might influence the thought or activities of the student body. The study indicates that there is a need for a more adequate control than was used. Some method which would test the "staying quality" of the changed attitudes would be valuable as it must be remembered that these students were tested the week after they had completed this area of study. The need for a method of studying a possible change in the overt behavior of the student is also indicated.

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A STUDY OF THE PERFORMANCE OF BASIC BIOLOGICAL SCIENCE STUDENTS IN ADVANCED BIOLOGY COURSES *

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As early as 1940 the general education movement seemed destined to expand itself into the continuance of the liberal and humane attitudes in the college curricula for the multitude of students. Although the idea of general education did not originate at Michigan State College, it was one of the pioneer schools in developing a comprehensive program for all undergraduate students.

In the spring of 1944 the movement resolved itself on the M.S.C. campus in the establishment of the Basic College with its seven new departments.[1]

This basic general education program was designed to give students an opportunity to explore broad fields of learning as a basis for selecting and studying special fields of emphasis. It also provided for all students a variety of contacts with those major fields of learning in which reasoned judgments are of prime importance to the growth of democratic society.

Dean Rather in his paper "General Education at a State College with Technologic Traditions"[2] has aptly expressed the prime objective of the Basic College as follows:

"The first objective of the Basic College program is to undergird the training of the specialist with a broad foundation of general education; in other words, to provide a common core of educational experience that with effective specialization for those students who require that type of intensive training in junior, senior, and graduate years. There is recognition of the need on the part of some members of society for highly specialized training. Also there is recognition of the fact that no one ever knew too much about his special field of interest. The Basic College program is designed to make sure that no undergraduate at Michigan State College follows a specialized program so intensively that in the end he knows too little of the relation of his own specialty to other activities and to the needs of society as a whole. It is designed to build specialized training, where desirable, on a broader foundation. It is designed to give each student—whether he be an eventual specialist or not—the opportunity for knowledge, skill, understanding, appreciation and thinking in diverse ways, so that he may develop as a well-rounded individual, capable of adjustment to changing conditions; capable not only of rendering service on a job, but also of utilizing effectively those nonwork, nonsleep hours that constitute so important a part of the good life."

Hence, a general education program was designed to develop an understanding of the liberal and humane traditions and to assist the student in realizing the importance of those ideas and ambitions which have been influential in the lives of men and basic to our civilization. This program to prepare youth to live effectively with changing social conditions stands in marked contrast to much of the specialized training offered in the senior colleges. It seems evident that both approaches to the educational process applies to a system of universal education.

It is probably true that emphasis on experimentation is a modern trend among educational institutions.[3] The contributions which the experimental method and other research techniques are making [4] in present day education have interested a large group of Basic College staff members in extensive testing of educational hypotheses.

* Contribution No. 30 from the Department of Biological Science, Michigan State College.

[1] The seven departments are: Written and Spoken English, Biological Science, Physical Science, Social Science, Effective Living, History of Civilization, and Literature and Fine Arts

[2] H. C. Rather, "General Education at a State College with Technologic Traditions." *Higher Education*, Vol. III, No. 18, May 15, 1947, pp. 1–4, concluded on p. 11.

[3] See the series of publications edited by Earl McGrath and published by W. C. Brown Publishing Co., Iowa City, Iowa. (Science in General Education, Social Sciences in General Education, etc.)

[4] The University of Minnesota Studies of General Education (M. S. Maclean, editor), present a good example of this point.

One department in the Basic College which is especially committed to experimental research is the Biological Science Department. Some of the exploratory studies completed in the department are "The Relation of Biological Science to Social Attitudes" [5], "Scientific Word Usage" [6], "Questionnaire Technique" [7], "Pre and Post Testing" [8], "Evaluation of Biological Science Objectives" [9], and "Examining in the Area of Biological Science"[10].

Purpose of this paper

Although the general course in Basic Biological Science is not primarily aimed at factual goals or the preparation of the students for advanced courses in Biological Science, many believe that completion of the general course is a distinct advantage to students who enroll in advanced biological science courses. Such a belief must be considered an hypothesis which the Biological Science staff intends to test periodically. It is the purpose of this paper to describe the results of an investigation designed to gather evidence concerning this hypothesis.[11]

Types and Sources of Data

From the record files of the Registrar, the Board of Examiners, and the departments concerned, the following data on several hundred students were gathered:

1. Scores of the American Council Psychological Examination.
2. Grades in Botany courses.
3. Grades in Zoology courses.
4. Scores on Comprehensive examination in Biological Science.
5. Term grades in Biological Science.

The score used from the American Council Psychological Examination (hereafter known as ACE) was the Total score (T), representing the sum of the Q score and the L score. The Q score purports to measure "quantitative" skills, significant in predicting academic success in scientific and technical curricula, while the L score indicates "linguistic" abilities, more significant for literature and social studies. The total raw score, regarded as a measure of general college ability, was transmuted to quintiles and used for roughly equating groups.

Grades in botany, zoology, biological science comprehensive and term grades were of the traditional A, B, C, type found on most campuses. All groups were roughly equated as to general learning ability by a random selection of an equal number of students from each quintile rank (ACE). Grade points conformed to the standard method of assignment: three grade points per credit for an A, 2 for a B, 1 for a C, 0 for a D, and minus 1 for an F. These procedures for equating, sampling, and scoring were used throughout the total study.

The one year Biological Science sequence consists of three terms of study numbered 121, 122, and 123 and hereafter referred to as Terms 1, 2 and 3.

Students who attained an A average for the first term or a B average for terms 1 and 2, were allowed to accelerate their study program by taking the comprehensive examination without completing all three terms. Thus Group I, those having Basic Biological Science, was subdivided into accelerated (Group 1-A) and non-accelerated (Group I-A_0) students.

FIRST COURSE IN ZOOLOGY SEQUENCE

The first science course in the upper

[5] M. D. Solomon and E. Braunschneider, "Relation of Biological Science to the Social Attitudes." *Science Education*, March, 1950.

[6] M. A. Burmester and J. N. Moore. "Scientific Word Usage," unpublished study in the file of the Biological Science Department, 10 pp., mimeographed.

[7] J. B. Gerberich and J. Mason, "Signed vs. Unsigned Questionnaire." *Journal of Educational Research*, October, 1948, pp. 122–126.

[8] J. M. Mason, "A Pre-test and Post-test Study in Biological Science." *Journal of Educational Research*, November, 1948, pp. 228–233.

[9] M. A. Burmester, "Evaluation of Biological Science Objectives." Master's Thesis, M.S.C., Spring, 1948.

[10] Clarence Nelson, "Examining in the Area of Biological Science," Chapter IV, in *Comprehensive Examinations in a Program of General Education*. M.S.C. Press, Spring, 1949.

[11] A grant from the All-College Research Fund was provided for some of the labor involved in gathering the data.

school selected for study was Zoology 207 in which were registered both students with (Group I) and students without (Group II), Basic Biological Science training.

Table I shows no statistical significance between students having and not having Basic Biological Science, (Groups I and II). Neither did Group II (not having Basic Biological Science) show any statistical significance when compared with Group I subdivisions (accelerated and non-accelerated students). However, when the mean scores of accelerated (I-A) and non-accelerated students ($I\text{-}A_o$) were compared, a statistically significant difference was obtained.

In an effort to explain this difference the question arose as to whether or not the process of acceleration was actually selecting a small group of high caliber students who, regardless of ACE scores, knew a great deal more Biological Science at the beginning of the Zoology 207 course than those students who were not accelerated. To answer this question groups of students were selected on the basis of the actual scores made on the Biological Science comprehensive examinations which served as a Pre-test and indicated the amount of Biological Science that various students had acquired previous to enrollment in Zoology 207.

Table II indicates the relative grade point averages made by accelerated and non-accelerated students who made A, B,

TABLE I

SUCCESS IN ZOOLOGY 207 OF MICHIGAN STATE COLLEGE STUDENTS HAVING THREE TYPES OF BACKGROUND EXPERIENCES

Pair	Group	N	Grade Point Average	Difference	Significant
1	II	105	1.295	.028	No
	I	157	1.267		
2	I-A	94	1.436	.287*	Yes (5%)
	$I\text{-}A_o$	114	1.149		
3	I-A	87	1.448	.081	No
	II	87	1.367		
4	II	95	1.252	.210	No
	$I\text{-}A_o$	95	1.042		

* Significant at 5 per cent level of confidence, using "t" test.

Group I = Having Basic Biological Science.
Group II = Not having Basic Biological Science.
Group A = Accelerated.
Group A_o = Not accelerated.
N = Number of students in each group.

TABLE II

SUMMARY OF GRADE POINTS PER STUDENT IN ZOOLOGY 207 WITH BACKGROUND OF 1, 2, AND 3 TERMS OF BASIC BIOLOGICAL SCIENCE

Comp. Grades in Basic Biological Science	Number of Terms of Instruction in Basic Biological Science					
	1 Term		2 Terms		3 Terms	
	N	Zoology 207 G.P. Ave.	N	Zoology 207 G.P. Ave.	N	Zoology 207 G.P. Ave.
A	7	2.285	14	2.142	21	1.952
B	20	1.300	40	1.325	60	1.266
C	14	1.142	28	1.142	42	1.000
Totals	41	1.414	82	1.402	123	1.292

or C, on the comprehensive. In each of these stratifications (A, B, C,) the grade point averages favored the accelerated groups. As an example it will be noticed that students who use only one term of instruction and who scored an A on the comprehensive made an appreciably higher grade point average in Zoology 207 than did students who had two terms of instruction and who also made an A on the comprehensive. Likewise it will be noticed that the "A" group of students with two terms of instruction had higher grade point averages in Zoology 207 than those who took three terms of instruction and who also made A's on the comprehensive exam. In general, those students who accelerated in Basic Biological Science received a higher grade point average in Zoology 207 than those students taking all three terms of Basic Biological Science. This difference between accelerated and non-accelerated students was tested by means of Fisher's "t" ratio and found to be significant at the 1% level.

In the light of these data it seems quite evident that the successful acceleration of students via the Basic Biological Science comprehensive examination is indicative of a factor of learning which continues to operate in advanced science courses. Furthermore, this factor is outside the realm of both general learning ability as measured by ACE and background knowledge in the subject as measured by the Basic Biological Science comprehensive examination used as a pre-test.

SECOND COURSE IN ZOOLOGY SEQUENCE

It was further decided to study students as they proceeded through a more advanced zoology course, namely, Zoology 208. Table

TABLE III

GRADE POINT AVERAGE IN ZOOLOGY 208 OF MICHIGAN STATE COLLEGE STUDENTS HAVING THREE TYPES OF BACKGROUND EXPERIENCES

Pair	Group *	N	Grade Point Average	Difference	Significant
1	I–AZ$_o$	38	1.605	.105	No
	II–Z	38	1.500		
2	I–AZ	70	1.728	.171	No
	II–Z	70	1.557		
3	I–Z	64	1.765	.265	No
	II–Z	76	1.500		
4	II–Z	51	1.450	.038	No
	I–A$_o$Z$_o$	51	1.412		
5	I–AZ	56	1.714	.109	No
	I–AZ$_o$	38	1.605		
6	I–AZ	45	1.777	.311	No
	I–A$_o$Z$_o$	45	1.466		
7	I–AZ$_o$	36	1.611	.139	No
	I–A$_o$Z$_o$	36	1.472		
8	I–A$_o$Z	58	1.758	.153	No
	I–AZ$_o$	38	1.605		
9	I–AZ	71	1.718	.183	No
	I–A$_o$Z	71	1.535		
10	I–A$_o$Z	76	1.710	.299	No
	I–A$_o$Z$_o$	51	1.411		

* Symbols:

Group I = Having Basic Biological Science.
Group II = Not having Basic Biological Science.
Group A = Accelerated.
Group A$_o$ = Not accelerated.
Group Z = Having Zoology 207.
Group Z$_o$ = Not having Zoology 207.
N = Number of students in each group.

III shows the various ways in which groups were selected and compared.

Although in no one instance was a statistically significant difference found, several observations are worth noting. First it will be noticed in pairs seven and nine that when the other two factors are controlled the accelerated group made higher grade point averages than the non-accelerated groups. This indicates support for the significant difference found between accelerated and non-accelerated students in Zoology 207.

Another point which may be observed in pairs one and four is that students who entered the advanced course, Zoology 208, with only Basic Biological Science as background did as well as students who had specific preparation for advanced zoology by having completed Zoology 207. However, as pointed out by the Zoology staff members, the reader must keep in mind that Zoology 207 has other values than mere preparation for Zoology 208.

On the other hand, the faculty advisor should consider the data revealed by pairs 2, 3, 5, 6, 8, and 10. In each of these pairs one group having both Basic Biological Science and Zoology 207 as background is compared with a second group having only one of these background experiences. In every case that group who had both, rated a higher grade point average. In general, it would seem wise for students planning to enroll in advanced zoology courses to be advised to complete Basic Biological Science as one of the basics offered for upper school admissions.

The students completing Zoology 208 were further studied in terms of high and low ability groups. In so classifying the students, "N" usually became so small that only very large differences in grade point averages would show up as being statistically significant. Nevertheless, it should be mentioned that the results suggested that the three factors were equally effective or ineffective regardless of the general quality of the student as measured by the ACE. In other words, students scoring in the first four deciles on the ACE were apparently benefited by additional background experience (either Basic Biological Science or Zoology 207) to as large or as little an extent as were students in the top four deciles.

As in the case of Zoology 207, students' data were organized, Table IV, to determine the effect of acceleration on A, B, and C students. Again, a statistically significant difference in grade point averages was found to favor the accelerated group. However, a new trend in the data appears. Accelerated students with two terms of Basic Biological Science tend to do better in Zoology 208 than those who accelerated at the end of one term. This would support the development of an important hypothesis, namely, that students who accelerate after two terms' work had learned the Basic Biological Science materials in a manner which continued to support excellent work in advanced courses. In other words, the useful retention of learned materials after two terms of study may be more substantial than that occurring after only one term of

TABLE IV

SUMMARY OF GRADE POINTS PER STUDENT IN ZOOLOGY 208 WITH BACKGROUND OF 1, 2, AND 3 TERMS OF BASIC BIOLOGICAL SCIENCE

	Number of Terms of Instruction in Basic Biological Science					
	1 Term		2 Terms		3 Terms	
Comp. Grades in Basic Biological Science	N	Zoology 208 G.P. Ave.	N	Zoology 208 G.P. Ave.	N	Zoology 208 G.P. Ave.
A	7	2.14	14	2.38	21	2.19
B	23	1.48	46	1.76	69	1.58
C	16	1.31	32	1.34	48	1.02
Totals	46	1.521	92	1.706	138	1.478

study. This trend was not evident when the grades of accelerated students, Table II, were computed for the *first* Zoology course following the completion of Basic Biological Science. However, one factor which might influence the validity of this hypothesis is the completion of Zoology 207. It is entirely possible that more of the two term accelerated students had completed Zoology 207 than either the one or three term students and thereby increase their chances of making high grades in Zoology 208. This possibility was thoroughly investigated. Since fewer (64%) of the two term students had completed Zoology 207 than either the one term (71%) or three term (67%) students it is obvious that the two term students had no advantage in this type of background study.

ADVANCED BOTANY COURSE SEQUENCE

In order to determine whether parallel results would be obtained in the other field of biology, students' performance in Botany 202 was studied.

Botany 202 is an advanced course in the upper school which has as a pre-requisite successful completion of Botany 101 or Botany 201. According to catalogue regulations students completing Basic Biological Science should enroll in Botany 201 before proceeding in the Botany sequence. Botany 101 exists specifically for students who did not choose to complete the Basic Biological Science course. The writer intended to study the success of students entering Botany 202 via these two channels. An examination of the Registrar's records indicated, however, that at *that* time most of the students were channeled through Botany 101 regardless of whether or not they had completed Basic Biological Science. It was necessary,

TABLE V

SUCCESS IN BOTANY 202 OF MICHIGAN STATE COLLEGE STUDENTS HAVING DIFFERENT TYPES OF BACKGROUND EXPERIENCES

Pair	Group *	N	Grade Point Average	Difference	Significant
1	$I\text{-}A_oB_1$	54	1.314	.018	No
	$I\text{-}A_oB_2$	27	1.296		
2	$I\text{-}AB_1$	85	1.729	.306	5%
	$II\text{-}B_1$	170	1.423		
3	$I\text{-}AB_2$	19	1.789	.004	No
	$I\text{-}AB_1$	29	1.785		
4	$II\text{-}B_1$	234	1.314	.059	No
	$I\text{-}A_oB_1$	94	1.255		
5	$II\text{-}B_1$	162	1.302	.006	No
	$I\text{-}A_oB_2$	27	1.296		
6	$I\text{-}AB_2$	19	1.789	.416	1%
	$II\text{-}B_1$	190	1.373		
7	$I\text{-}AB_1$	50	1.760	.464	1%
	$I\text{-}A_oB_2$	27	1.296		
8	$I\text{-}AB_2$	15	1.733	.133	No
	$I\text{-}A_oB_2$	15	1.600		
9	$I\text{-}AB_2$	19	1.789	.544	5%
	$I\text{-}A_oB_1$	57	1.245		
10	$I\text{-}AB_1$	66	1.666	.273	1%
	$I\text{-}A_oB_1$	66	1.393		

* Symbols: I = Having Basic Biological Science.
II = Not having Basic Biological Science.
A = Accelerated.
A_o = Not accelerated.
B_1 = Having Botany 101.
B_2 = Having Botany 201.
N = Number of students in each group.

therefore, to study several groups of students, many of whom were small in number, since few students elected Botany 201. Table V shows the ways in which groups were selected and compared.

Several instances will be noted where a statistically significant difference was found. The reader will observe that in pairs seven, eight, nine and ten, the accelerated groups made a higher grade point average than the non-accelerated groups. These differences were statistically significant for pairs seven, nine, and ten, and supports the significant differences found between accelerated and non-accelerated students in Zoology.

Pair six yields another significant difference where accelerated students who entered the advance course Botany 202, with Basic Biological Science plus Botany 201 as background performed significantly better in Botany 202 than students who had no Basic Biological Science but completed Botany 101 prior to their entrance into Botany 202.

On the other hand data for pairs four and five suggest that non-accelerated Basic Biological Science students perform no better than students who have not had Basic Biological Science. This is further evidence that acceleration is related to high performance in advanced study. It perhaps suggests that non-accelerated Basic Biological Science students should take the same botany preparatory course as required of the non Basic Biological Science students.

In this connection we should also consider the data revealed by pairs one and three. In general, these data indicate that it makes no significant difference in performance in Botany 202, whether Basic Biological Science students enroll in Botany 101 or 201 as a background for advanced Botany study. These studies indicate further that there is no logical reason for the continuance of Botany 101 and 201 on this basis. However, since the data for this report were obtained, the Botany department has independently adopted a different policy regarding Botany 101 and 201. As now organized, all students who have successfully completed Basic Biological Science are channelled through Botany 201, whereas those without this background are restricted to Botany 101. Moreover, Botany 201 is reorganized to take advantage of the skills and attitudes acquired by students in completing the Basic Biology series. Future studies of student performance in advanced courses will be needed to evaluate the results of this new policy. It would also seem worthwhile to experiment with the accelerated Basic Biological Science students by allowing them to enter Botany 202 without either of the prerequisite courses.

This recommendation is a result of the data in Table V, plus the fact that in Zoology where Basic Biological Science students do have an opportunity to take advanced courses without further prerequisites, accelerated students do not appreciably improve their performance in advanced

TABLE VI

SUMMARY OF GRADE POINTS PER STUDENT IN BOTANY 202 WITH BACKGROUND OF 1, 2, AND 3 TERMS OF BASIC BIOLOGICAL SCIENCE

	Number of Terms of Instruction in Basic Biological Science					
	1 Term		2 Terms		3 Terms	
Comp. Grades in Basic Biological Science	N	Botany 202 G.P. Ave.	N	Botany 202 G.P. Ave.	N	Botany 202 G.P. Ave.
A	4	2.25	8	2.250	12*	1.583
B	13	1.769	26	1.615	39	1.307
C	8	1.625	16	1.500	24	1.166
Totals	25	1.800	50	1.680	75	1.306

courses by electing additional preparatory courses.

As in Zoology 207 and Zoology 208, students' grade point averages for Botany 202 were organized to determine the effect of acceleration on students who score A, B, or C on the Basic Biological Science comprehensive examination. As in Zoology, a statistically significant difference in grade point averages in favor of the accelerated groups was found. There appears to be no tendency for one term accelerated students to exhibit a loss in the retention of useful Basic Biological Science knowledge. It is possible that this may be accounted for by the fact that all Basic Biological Science students had their memories refreshed by a preparatory course in Botany, either 101 or 201.

SUMMARY

1. In general, students who accelerate in Basic Biological Science receive a higher grade point average in Zoology 207 than those students taking all three terms of Basic Biological Science. This trend is continued in advanced Zoology.

2. Successful acceleration of students via the Basic Biological Science comprehensive examination is indicative of a factor of learning which continues to operate in advanced science courses.

3. The acceleration factor is outside the realm of both general learning ability as measured by ACE and background knowledge in the subject as measured by the Basic Biological Science comprehensive examination used as a pre-test.

4. There appears to be a definite trend for students who entered the advanced course, Zoology 208, with only Basic Biological Science as background to do as well as students who had specific preparation for advanced Zoology by having completed Zoology 207.

5. Students having both Basic Biological Science and Zoology 207 as a background for Zoology 208 rate a higher grade point average than students having only one of these background experiences.

6. Accelerated students who have had Basic Biological Science do not appreciably improve their chances for higher grades in Zoology 208 by first completing Zoology 207.

7. Non-accelerated students materially increase their chances for higher grades in Zoology 208 by first completing Zoology 207.

8. Students in the first four deciles on the ACE taking Zoology 208 were apparently benefited by additional background experience (either Basic Biological Science or Zoology 207) to as large or as little an extent as were students in the top four deciles.

9. Accelerated students with two terms of Basic Biological Science tend to do better in Zoology 208 than those who accelerated at the end of one term. This trend was not evident when the grades of accelerated students were computed for the first Zoology course (207) following the completion of Basic Biological Science.

10. Significant differences in grade point averages were found in favor of the accelerated over the non-accelerated Basic Biological Science students in Botany 202.

11. Accelerated Basic Biological Science students having Botany 201 perform significantly better in Botany 202 than students having no Basic Biological Science but completing Botany 101 as a background prior to entrance into Botany 202.

12. It makes no significant difference in performance in Botany 202, whether Basic Biological Science students enroll in Botany 101 or 201 as a background for advanced Botany study.

13. Non-accelerated Basic Biological Science students perform no better than students who have not had Basic Biological Science in Botany 202.

IMPLICATIONS

Some universities have not been giving credit for courses passed off by comprehensive examinations. Their consideration is only devoted to accepting credit for work

completed in course attendance. In the light of this study it seems quite evident that the successful acceleration of students, via the Basic Biological Science comprehensive examination, is indicative of a factor of learning which continues to operate in advanced science courses. This factor was found to be outside the realm of both general learning ability, as measured by ACE, and background knowledge in the subject as measured by the Basic Biological Science comprehensive examination used as a pre-test. It is entirely possible that admission officers for professional schools, such as medical, dental and veterinary medicine, etc., would be interested in having this type of information to aid them in selecting the most promising students.

Zoology

1. Faculty members who are advising students who have completed Basic Biological Science and who are trying to decide whether to enroll in Zoology 207 or Zoology 208 should consider that students who enter Zoology 208 with only Basic Biological Science do as well as students who had only Zoology 207. However, students who have both Basic Biological Science and Zoology 207, rate a grade point average higher than either group offering only one. Any student planning to enroll in advanced zoology courses might well be advised to complete Basic Biological Science as one of the basics for upper school admission unless there are more important reasons. The advisor should also be aware of the fact that accelerated students do not appreciably improve their chances for higher grades in Zoology 208 by first completing Zoology 207. This leaves the non-accelerated students who do materially increase their chances for higher grades in Zoology 208 by first completing Zoology 207.
2. The useful retention of zoological knowledge after two terms of study may be considered as more substantial than that following one term. The implication follows from the data in Table IV. This hypothesis as to whether the students who accelerate after two terms had learned Basic Biological principles in a manner which continued to support excellent work in advanced zoology courses, might well be a factor for student consideration, as to the time of acceleraton. Faculty advisors should be aware of this trend.

Botany

1. Since it made no significant difference in Botany 202 whether Basic Biological Science students enroll in Botany 101 or 201 as a background for advanced botany study, it is evident that there was little justification for two courses on this basis. Under the new plan adopted by the Botany department, students who have successfully completed Basic Biological Science now have in Botany 201, a course organized to take advantage of their skills and attitudes already acquired. This is a forward look in the eyes of most staff members and merits further study of the problems involved in integrating general education courses with existing upper school offerings.
2. One might imply that an opportunity to experiment with the accelerated Basic Biological Science students by allowing them to enter Botany 202 without either of the prerequisite courses, at least warrants consideration. This implication follows from the data in Table IV and VI, plus the fact that this opportunity in Zoology has not injured students' grades. By comparison the accelerated students do not appreciably improve their performance in advanced courses by electing additional preparatory courses.

THE PHYSICAL SCIENCE SURVEY COURSE IN GENERAL EDUCATION

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THE first requisite of an efficient physical science survey course is proper teaching personnel. This is more true here than in any other college undergraduate course. Nowhere else in the curricula is there as strong a need for men and women with enthusiasm for the subject, teaching, and people.

Too often, instructors, in the physical science survey course are imbued with the thought that assignment to the subject is a demotion, or is not worth the time and effort it demands. Present, too, are those who have a measure of contempt for the aspiring social study major. Equally dangerous are the ones who carry with them the point-of-view of educating scientists and engineers.

Proper personnel is not so much a matter of having a specialist, a "name" scientist, or a scholar. It means teachers with the gift of exposition. Clarity of presentation is more important than confronting students with the authorities. The celebrated specialists generally do not have the dramatic ability and showmanship to make a crystal-clear explanation more graphic and vivid. Proper personnel means instructors who can engender inspiration; who can gain attention and maintain interest. Exciting the student about physical science is more important than giving a glimpse of Nobel prize winners. It means above all men and women who have a kindly feeling for young people. The social work of individual instruction is by far a most vital factor. Indeed, those without affection for students will never be a credit to the teaching profession, and certainly not to the most difficult area of instruction, popular science.

The formulation of broad goals, content, and methods is a second necessity. To proceed aimlessly with unclassified ammunition and spontaneous strategy is foolish.

Physical science survey courses are seldom, if ever, intended for prospective scientists. Therefore, science for non-scientists should be an uppermost thought. If there are to be any general aims, that phrase, "science for non-scientists" contains a basic one.

Presumably, physical science is a more or less distinct sector of knowledge. But the term, "non-scientist" requires definition. One fairly-accurate description is—anybody who hates science.

With this consideration, a course in physical science can begin with subtle attempts to remove hate and fear. It could well discuss first the scientific spirit, the attitude carried by some naturalists. Spiced with incidents from the lives of scientists, this can promote initial good-will and capture attention. To maintain interest, the account can be followed by simple, everyday descriptions of scientific method in action. The dullest as well as the most anti-science student can be intrigued by well-knit tales illustrating the place of hypothesis, the meaning of experiment and empiricism, cause-effect sequences, and the entire fabric of methodology.

A preliminary presentation of scientific method and attitude can serve as the base for further exploration and re-emphasis. Throughout the year's work, fundamental ideas can be surveyed from this angle. There should be no let-up in teaching scientific method, from the very first day until the last.

The initial semester of physical science usually contains descriptive astronomy, meteorology, and geology. This can and should be integrated. One obvious way is the painting of a picture of the world. The canvas can be painted without using mathe-

matics. This worth-while discipline produces symptoms of hysteria if introduced too early in a program of science for non-scientists. Likewise any reference to the theory of relativity should be postponed.

The corrosive influence of fear should be checked and removed before embarking upon a consideration of matter and energy, because the key to further deciphering the picture of the world is a set of chemistry and physics abstractions. Scientific abstractions can best be absorbed by the non-scientist when free of preconceived prejudices about them.

The classical treatment of elementary physics and chemistry in physical science survey is inefficient. It separates this portion of the course into a predetermined number of weeks of each specialty. The result can often be readily-forgotten surface samplings.

Two fine threads can be used to show the unity of chemistry and physics. One is correlation via four basic ideas. After a study of the states of matter and of heat energy, the molecular theory can be introduced to unify. Following the essentials about materials, the atomic theory can be a further guide. The electron theory should come with the treatment of electrical energy. Thus, students can leave the sequence with the basic concepts of mechanics and three interpreting mechanisms, rather than a myriad of unrelated facts.

Another unifying thread, useful as an adjunct correlating device, is the concept of energy. Here, the network of data can be tied to potential and kinetic forms; to radiant, chemical, electrical, mechanical, heat, and supersonic varieties; to units of energy and philosophical considerations of its significance.

The amount of material to be presented is a vital area in course content considerations. An equally allied factor is the method of presentation. The axiom, "It's not what you say but how you say it" could well be paraphrased, "It's not what you teach but how you teach it". For even with course content, goals, and teaching personnel excellent, the survey course needs proper teaching techniques.

One could quote that bane to organized education, G. Bernard Shaw: "If you teach a man anything, he will never learn". So perhaps we should teach as though we teach not. More apropos,, nineteenth-century-chemist Justus Liebig said, "Students are not receptacles to be filled. They are fires to be kindled". Since his time, mounting amounts of scientific information have overwhelmed student, teacher, and layman. Courses in technology and science have become baskets full of data. Too often, the subject of physical science for the prospective non-scientist takes on this raw flavor.

Obvious as well as subtle means exist to sweeten the diet of physical science. Undoubtedly, it would be a Herculean task to carry on without the aid of selected slides, film strips, and sound films. Then, an excess of minute and advanced facts is to be avoided. Future business leaders and teachers need not be subjected to a score of generalizations about the periodic table. There is no point to teaching theoretical mechanics or undiluted physical chemistry.

What information is given can always be simplified. Potential attorneys and housewives can be just as happy and educated without learning the precise phraseology of paleontology.

One great aid to simplicity is the employment of slang words and phrases. The loss in accuracy is repaid manyfold by the gain in interest and understanding.

Common parlance and some argot of the street can be viewed as an attempt at interjecting humanism. It brings to the subject some of the pleasantries which make for warmth and companionship. These same elements and others of humanist science can be introduced through other avenues.

Mention of science in the classics of literature is always helpful. In almost every masterpiece can be found a reference

to physical science. It can be Shakespeare's "night's candles are out and jocund day stands tiptoe on the misty mountain tops", or Milton's "broad and ample road whose dust is gold and pavement stars". Eclipses are mentioned in the Bible and in Homer's Ulysses. Faraday's diary or Galileo's dialogue can serve the purpose of literature and science at the same time.

Literature is not the only connecting link between science and other disciplines. Politics, economics, and other social studies are today irrevocably intertwined with physical science. The social significance of science is today, more than ever before, a grave and meaningful topic. So important is this area that an entirely separate course of study can be fashioned from the wealth of existing data.

The physical science survey teacher may be able to bring forth, at any class session, illuminating ideas about science and society. For example, science and the industrial revolution, Marxism and science, science and militarism, or the atomic revolution have plenty of stirring thoughts for students and teachers.

Perhaps this illustrates, too, that any one subject, such as physical science, if taught properly, can serve as the introduction to many others, seemingly unrelated. Schools make barriers between fields of knowledge and disciplines. Schools should begin removing these artificial lines of demarcation.

Besides the social significance, the very related personal import of science can be stressed. The popular magazines of science can here offer aid and material. The gadgets and features they promote are slanted to interest the individual.

The aim of the course is to prepare laymen alert to science and its developments. One way for them to remain intelligent in the field is to keep abreast of popular scientific literature. To inculcate this habit, students should be required to prepare a three to four page book report each term. This task demands evaluation from the popular science point-of-view, and secondarily, from the literary. The review evaluates such items as scientific ideas presented, method of presentation, and significance in the framework of science.

Another, often neglected, aid to season the diet of physical science is humor. Physical scientists and their area of knowledge are too frequently publicized as austere and humorless. Actually, the scientists whom Wilhelm Ostwald in his "Grosse Leute" has characterized as of the romantic type, are the reverse. Thus the demonstrative laughter of Einstein or the practical jokes of R. W. Wood need to be simulated by the physical science instructor. They may bring a point to focus; they may bring more humanism to science.

The lighter vein is only part of a well-planned teaching strategy. But any strategy is useless and foolish if students are not diligent and cooperative. The best teacher and the best techniques are wasted with students who do not contribute their share to the learning process. This is an arduous task; the teacher can only lighten the load a bit. Together with other essentials it can bring results: Non-scientists can be given a better perspective of science than has the average major in chemistry or physics. When this is true of the bulk of the liberal arts and commerce graduates, the physical science survey course will have served well in the program of general education.

FOREIGN PERIODICALS AND RESEARCH IN SCIENCE EDUCATION

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THE intercommunication of ideas and observations implemented by the wartime widespread dispersal of American educators and students of education has nurtured increasing interest in foreign educational systems. Extension of the "One World" concept implies increased familiarity with the educational practices of all nations and governments. This article presents brief introductions to what may be considered "beginners" periodicals published by Great Britain, Germany, Russia, France, and Japan.

This article does not provide references to periodicals which report advanced professional or academic research. The references were chosen upon the criterion of contributing to a better understanding of classroom teaching and educational systems in other countries. In addition, brief references are made to periodicals reporting research in science and composed in such manner as to be readily interpretable without too broad a background in a specialized science. The author assumes that as one follows a study through the periodicals cited, references will be acquired to more advanced and specialized publications.

Great Britain. The *Journal of Education* [1] is described as a monthly record and review with which is incorporated the *School World*. Examination of recent copies of *The Universities Review* [2] reveals such titles as "Industry and the University Graduate", "The Centenary of the Chemical Society", "Relation of the Home Universities to Colonial Universities and Colleges", and "The Functions of the University". The December, 1939, issue of *School Science Review* [3] included such titles as "Allotrophy", "Entrophy and the Universe", and "Erasmus Darwin and the Teaching of Science". Representative issues of *Nature* [4] which appeared in the spring of 1948 contained articles with such titles as "The Status of the Protozoa", "The Artificial Production of Mesons", "Adsorption and Heterogeneous Catalyses", and "The Draining of Binley Lake and Its Ecological Consequences".

Germany. *Die Schule*,[5] *Die Neue Schule*,[6] and *Freie Volksbildung* [7] provide general information regarding education in Germany. During 1942 representative articles appeared in Naturwissenschaften [8] with the titles "Über die Bildung und Aktivierung des Wuchsstoffes in den höheren Pflanzen", "Das Verhältnis von Mathematik, Naturwissenschaften und Technik zueinander", and "Induktive und teleologische Psychologie". Postwar issues of *Natur und Volk*,[9] a periodical specializing in the biological sciences, include the titles "Klein Lebensgeschichte des Heide-Ringelspinners", "Neue Ergebnisse der Relativitats-Theorie", "Neue Kapillarbilder", and "Das farbige Raumbild mit

[1] *Journal of Education*, Amen House, Warwick Square, London, E.C. 4, Monthly, 15s. per year post free.

[2] *The Universities Review*, Organ of the Association of University Teachers, J. W. Arrowsmith, Ltd., Quay Street and Small Street, Bristol, 3 times a year, 3s. 6d.

[3] *School Science Review*, J. Murray, 50 Albermarle Street, London, W.C. 1, 3 times a year, 11s. 6d.

[4] *Nature*, Macmillan & Co., Ltd., St. Martin's Street, London, W.C. 2, weekly, £4:10:0.

[5] *Die Schule*, Druckerei H. Osterwald, Stiftstrasse, 2, Hanover, 1:50 RM Monthly.

[6] *Die Neue Schule*, Volk und Wissen, Verlags GMBH, Berlin. 60 Pfennig per issue. Bi-monthly.

[7] *Freie Volksbildung*, Leibniz-Verlag, Bisher R. Oldenbourg, Munchen, Germany. Monthly, 39 RM plus postage.

[8] *Die Naturwissenschaften*, Arnold Eucken, Springer-Verlag, Berlin, Germany. Semimonthly, 24 RM.

[9] *Natur und Volk*, Verlag von Dr. Waldemar Kramer, Frankfurt, Germany. Quarterly, 2 RM per issue.

einfachsten Mitteln". No recent copies of the *Zeitschrift fur Mathematischen und Naturwissenschaftlichen Unterright*[10] were readily available to the author. However, for historical reasons, since this periodical was founded in 1869, its citation was deemed advisable. Representative 1916 issues place major emphasis on mathematics but science titles include "Artilleristiche Problems im Schulunterricht", "Über physikalische Schülerübungen und deren Verwertung im Unterricht", and "Gedanken und Erfashrungen zur praktischen Ausbildung der Lehramskandidaten für Physik".

Russia.[11] Whether the lack of availability of Russian periodicals is associated with the lack of emphasis that has been placed on providing opportunities to learn the language is problematical. The author considers it justifiable to recall the observations serving as an introduction to this article preparatory to presenting the Russion periodicals.

Pedagogika[12] appears under its English name *Pedagogics* and with *Narodnoe obrazovanie* (Public Education)[13] and *Sovetskaia pedagogika s prilozhen* (Soviet Pedagogies with Supplement)[14] present articles dealing with general education. Representative titles appearing in this latter periodical during 1947 are "Problems of the Schools and Improvement of the Pedagogic Preparation of Teachers" and "New Curricula of the Pedagogic Colleges and the Raising of the Quality of Preparation of the Intermediate Schools". *Vestnik Vishsshey Shkoly* (Messenger of the Higher Schools)[15] holds interest for students in science education as evidenced by such titles appearing in a 1948 issue as "An Active Militant Campaign for the Priority of Our Native Science", "About the Activities of the KOMOSOMOL (Communistic Soviet Youths' School)", "Raising the Requirements for Doctors' Dissertations", and "Red-Tape, and Disrespect for Scientific Duties". *Estestvoznanie v shkole* (Natural Science for Schools)[16] has specialized interest for science education. Representative 1947 issues of *Priroda*[17] contain such titles as "Electronic Theory in Organic Chemistry", "Formation of Coal Fields", "On the Vegetation on Mars", and "Agriculture in the High North". *Nauka i zhizn'* (Science and Life)[18] is recommended for its reports of research in science.

France. Among the titles appearing in a representative 1948 issue of *Revue Universitaire*[19] are "L'utillisation du dessin dans l'enseignment des sciences naturelles", "Le rèlevement de la culture dans les pays dévastis par la guerre", and "L'enseignment scientifique donné an lycée est-il efficace?" In addition to the significance indicated by the title, the *Journal of Mathematiques Elementaires*[20] usually contains practical and interesting problems with implications for chemistry and physics. *La Nature*[21] presents articles bearing such titles as "Micro-Météorologie et Micro-Climatologie", "Les Serpents Venimeux et le Traitement de Leurs Morsures", "La Resistance Aérodynamique des Véhicules",

[10] *Zeitschrift fur Mathematischen und Naturwissenschaftlichen Unterricht.* Verlag von B. G. Teubner, Berlin. Monthly.

[11] Russian periodicals may be obtained from either of these addresses:

Mezhunarodnaia kniga Moscow
Kuznetskii most
18 Moscow, U.S.S.R.

Four Continent Book Corporation
253 Fifth Avenue
New York 16, New York.

[12] *Pedagogika,* monthly.

[13] *Narodnoe obrazovanie,* monthly. $3.00.

[14] *Sovetskaia pedagogika s prilozhen,* monthly. $6.00.

[15] *Vestnik Vishsshey Shkoly,* monthly.

[16] *Estestvoznanie v shkole,* bimonthly. $2.40.

[17] *Priroda,* bimonthly. $7.00.

[18] *Nauka i zhizn',* monthly. Illustrated. $3.00.

[19] *Revue Universitaire,* Librairie Armand Colin, 103 bd. Saint Michael, Paris (Ve). Bimonthly. 350 fr.

[20] Journal de Mathematiques Elementaires, 63 bd. Saint-Germaine, Paris (Ve.). Bimonthly. 210 fr.

[21] *La Nature,* Masson & Cie, Editeurs, 120 bd. Saint-Germaine, Paris (VIe). 1st and 15th of each month. 500 fr.

and "Déparaffinage des Huiles Minérales par Autoréfrigération".

Japan. The author is unable to personally review copies of Japanese periodicals. He does not, however, desire to contribute to any tendency to neglect the Japanese education system as a fertile field for science education research. Hence he takes the liberty to offer the citations provided by John R. Shively, Chief of the Japanese Section of the Library of Congress. Journals of general interest to educators include *Mombu Jiho* (The Education Ministry Review),[22] *Kyôikukai* (The Educational World),[23] and *Kyôiku* (Education).[24] *Nippon Kyôiku* (Japanese Education)[25] is described as an overall magazine for elementary schools. *Shizen Gakushû* (Nature Study),[26] *Kyôiku Kenkyû* (Teaching Techniques),[27] and *Chûtô Kyôiku* (Middle School Education)[28] are recommended as being of special interest in science education.

Several interesting questions became apparent as the work of preparing this article progressed. Is the status of education in the other countries of such stature as to justify reading their periodicals? Does the level of language ability normally associated with the foreign language reading requirement for doctoral degrees permit reading these periodicals with facile understanding? Are English translations of the articles appearing in these periodicals available? Is one conducting research in science education considered provincial if he is not familiar with pertinent periodicals published in other major countries?

The author purposes no answer to these questions. In the pursuit of another study, difficulties were encountered in finding data regarding foreign periodicals comparable to certain American publications. It is hoped that this report will resolve similar difficulties as, and if, they are encountered by other students of science education.

[22] *Mombu Jihô*, Mombu-shô, Tokyo.
[23] *Kyôiku-kai*, Nihon Kyôiku-kai (Japan Education Association), Tokyo.
[24] *Kyôiku*, Iwanami Shoten, Tokyo.
[25] *Nippon Kyôiku*, Kokumin Kyôiku Tosho Kabushiki Kaisha, Tokyo.
[26] *Shizen Gakushû*, Kokumin Kyôiku Tosho Kabushiki Kaisha, Tokyo.
[27] *Kyôiku Gijutsu*, Shôgakukan (Elementary Education Institute), Tokyo.
[28] Chûtô Kyôiku, Kanda-ku, Iwamoto-chô 3, Tokyo.

VISUAL AIDS IN TEACHING ABOUT POLIOMYELITIS

Anatomical drawings relating to infantile paralysis are now available to teachers of biology in high schools and colleges. These were executed by Dr. Frank H. Netter and originally appeared in the August 14, 1949, issue of *Life*. For the secondary school level, the drawings may be used to supplement a Science Unit on Poliomyelitis, comprising a source book for students, a teachers' guide, and a 39-frame filmstrip. Requests for these teaching materials, which are furnished without charge, should be made to Education Service, National Foundation for Infantile Paralysis, 120 Broadway, New York 5, New York.

NATURE AND CONTENT OF BROCHURES NEEDED IN TEACHER EDUCATION PROGRAMS

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One of the appalling weaknesses in preservice education of teachers has to do with the lack of instruments to provide various essential types of informations. In a number of investigations, teacher trainees, as well as others connected with teacher education, have repeatedly indicated that a lack of needed informations contributes materially to a serious obstacle for a smoothly running program.

A question immediately presents itself with respect to what kinds of information are needed by our trainees. It is a purpose of this paper to consider especially such necessary documents or brochures as would serve to clarify what is expected of trainees in student teaching, to assist cooperating teachers in professional orientation, and to set the stage for better relationships with selected school facility units for student teaching. In addition, some reference will be paid to the types of informations which trainees feel are most deficient, or which need improvement, or amplification.

At the outset, it should be emphasized that more painstaking efforts should be extended toward preparing attractive and colorful brochures. The tendency to mimeograph dull and drab material has long been too apparent. Trainees are human, too, with respect to reading interest and can be expected to react more favorably to directives prepared in attractive and appealing format. Thus, it should pay huge dividends to make our informational materials interesting, picturesque, and attractive, with colorful pictures or illustrations. Industry long ago discovered that attractively prepared brochures serve as excellent media to accomplish significant objectives and goals. We in teacher education should certainly study exploitation of such approaches to implement our teacher education programs through better understanding and through maximum clarity.

In an attempt to plan for better brochures of information, the writer set up an investigation to ascertain opinions relative to the type of brochures needed and some possible contents of each. A questionnaire was submitted to 105 teacher educators asking for recommendations about the types of information which could and should be supplied our trainees and colleagues via brochures. Ninety-two usable replies were received. In addition, 350 student teachers were asked to submit a list of recommendations for better informational service about the preservice program which could plausibly be included in informational brochures.

There was apparent concentration of recommendation from the two sources for six different brochures. A list of the six along with some suggestions for content follows:

1. A recruitment bulletin.
   Materials prepared for recruitment purposes should include discussions about who should go into teaching, the rewards, the satisfactions and the normal expectations. Such a brochure should face quite frankly the logical questions which occur in the thinking of one who is considering teaching as a vocation. Opportunities and limitations in the field can be put in interesting form along with some treatment of professional experiences of training which will be provided. Abundant pictures of typical school settings and school-community enterprises serve well to encourage careful consideration of teaching as a profession.
2. A directive for student teachers.
   Perhaps this is the most important

of the brochures and contact with such a bulletin should not be reserved until the time of student teaching. Rather, it can serve well for orientation a year or more prior to student teaching experiences. Such fundamental topics as what is expected of the student teacher, the types of experiences which will be provided in the program, the general philosophy for the importance of student teaching, and experience advisable or required prior to student teaching should be included. Where appropriate, information regarding the professional semester, about which student teaching serves as a core, and problems of adjustment and preparation for off-campus resident student teaching becomes very helpful.

3. A directive for cooperating schools. Rapport and cooperation with cooperating schools who supply facilities for student teaching can be enhanced appreciably through usage of brochures which treat expectations which the training institution holds for the cooperating school, as well as those which the cooperating school logically realizes from the training institution. Criteria for selection of cooperating schools, and the professional contribution of helping to train their own workers can be emphasized. The prestige and opportunities for service developed for the cooperating school are fertile topics to consider.
4. A directive for cooperating teachers. Much gain could be accomplished through a bulletin which anticipates and answers most of the problems which will be encountered by cooperating teachers. Criteria for selection of cooperating teachers should be included. Treatment should be given the opportunities and privileges accruing from serving as a cooperating teacher to whom student teachers have been assigned for actual student teaching, as well as professional satisfactions. Exuberant and enthusiastic teaching is a likely dividend from such a brochure.
5. A directive for supervisors and counselors.

   The work of the supervisor and the counselor should be carefully outlined in such a bulletin. The use of counseling devices, the importance of the cumulative folder, and techniques of counseling should be treated. The entire philosophy for and objectives of the counseling should be included. Special treatment of the work of the supervisor and his relation to the cooperating teacher can also be profitably developed.
6. A bulletin dealing with the new philosophy for student teaching, and for teacher education.

   Newer trends, problems to be solved, what's in the literature, and planning for improvement of the teacher education program all form functional content for a bulletin on teacher education. The entire staff concerned with teacher education needs to be kept apprized of changes, trends, and problems facing teacher education.

Some suggestions were offered by various respondents which are appropriate and germane to the task of supplying essential information. These follow:

1. There is vital need for a newsletter for student teachers and for cooperating teachers, to be published at frequent and regular intervals.
2. Statewide or regional cooperative efforts should be inaugurated to prepare bulletins of information which with minor changes could serve a group of institutions.
3. Brochures of information should be stockpiled in workshops on teacher education for the purposes of appraisal and improvement of them.
4. Committees, commissions or some central office should compile samples of brochures for loan to institutions

who are engaged in preparing brochures for their own usage.

5. Brochures should represent the joint efforts of committees in which there is representation of teacher trainees, professional faculty members, academic faculty members, and cooperating school officials.
6. Schools should exchange copies of brochures with other schools and encourage exchange of ideas for improvement.
7. Educational journals should carry more of help toward preparing informational brochures.
8. Systematic and regular inquiry should be promoted among students and staff members to ascertain what additional informations are needed.
9. Promotion of research to learn answers to problems and questions should be a normal outgrowth of experience in preparing informational brochures.
10. Commissions and committees dedicated to the improvement of teacher education should assist us in preparation of these brochures.
11. Brochures should be in a numbered and related sequence for trainees.

It should be emphasized that the brochures suggested in this discussion are in addition to and separate from courses of study, syllabi, and evaluation instruments. These latter groups are integral adjuncts of courses and fall under a slightly different category than the general informational brochures.

Thus we have before us a challenge and set of goals, that of insuring against lack of essential informations and directives for the effective functioning of our teacher education programs. It is true that each institution may not need all six, and also that there may be need for others than the ones listed in this paper, dependent on the unique needs or conditions of a given situation. But there is apparently adamant desire on the part of trainees and our cooperating groups to have better orientation and directive through well organized materials, and the printed brochure is a logical answer to the need. Teacher training institutions have many demands upon their resources, but it would probably be well for each one to re-examine its status toward meeting informational needs and delegate some resources to the task of improving the informational materials as needed.

MAN AND HIS ENVIRONMENT

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THE above title is one which has served as an organizing center around which to build a course for student nurses. In recent years, much discussion has been carried on concerning needed integration in our school and college courses. The tendency to specialize has been so strong among teachers that students often feel the need for more understanding of the relations of course materials to life. New discovery in every abstract field needs concentration—specialization; but everyday use of discovered knowledge necessitates definite attention to functional use. Modernization of our school curriculum and courses in order to invite pupils' minds to the understanding of new knowledge, may reasonably adopt new titles for the courses offered.

When I taught high-school physics in a large Minneapolis high school, one of the pupils—not one of the best, I admit, frankly asked me, "What's the use of this 'junk', anyway?" There is probably no more useful knowledge in daily life affairs than content classified under high-school physics. To be sure, this has been realized by many instructors, and we have seen gradually de-

veloped courses in general science for the upper grades, and elementary science for lower grades.

But the term "science" is not one which immediately makes clear to pupils, relations of course materials to functional living. There is a demand for more revealing titles, and, in some educational institutions, the demand is being met in degree.[1]

This is a brief account of the organization of two courses at the Medical College in preclinical nursing. They constituted a recommended sequence: "Man and His Physical and Biological Environment"; and "Man and His Sociological and Psychological Environment". The last-named was actually taught as a teaching experiment during the school year 1947–8, to a class of about 50 students.

The title was designed to suggest the course objectives—to learn more about man—people—with particular attention to the sociological and psychological aspects of the environment. Students were assigned the general task of collecting principles and generalizations concerning man and his sociological and psychological environment; and an extensive bibliography was given them for suggestions.

As a special text for the course, a list of 1305 generalizations selected from eighteen different text-books, written for nurses, was distributed. Daily classes were conducted around study and explanation of these generalizations. Special attention was given to illustrative cases which applied the generalizations in daily life. The generalizations were classified under the following titles:

1. Foundations of Human Society
2. The Reactions of Society and the Individual
3. Social Functions and Relationships
4. Economics of Social Life
5. Some Aspects of Family and Marriage
6. Delinquency, Crime, Ethics, Religion
7. Group Psychology
8. Social Intercommunication
9. Use and Abuse of Language
10. Nursing and Health Records
11. Biological Foundations of Behavior
12. Psychological Aspects of Personality and Behavior
13. Perception, Habit, Motivation, Attitude, Adjustment
14. Some Psychological Implications for Care and Prevention
15. Some Reflections on Mental Illness
16. The Nature and Process of Education
17. Some Aspects of Learning Capacity, Guidance, and Permanence of Learning
18. Science, Nursing, and Other Aspects of Functional Education

The point we wish to stress is that discussion was carried on—students and instructor collaborating—around the meaning and significance of principles and generalizations. The stage being set for insight into the meaning and significance of generalizations, as contrasted with too exclusive attention upon details of facts or discoveries, the matter of evaluation of student achievement was a natural procedure.

Evaluation or achievement tests were constructed around a selection of generalizations. Naturally, we could not include evaluation on all of the 1305 generalizations, so we adopted the plan of random selection. We drew 100 generalizations from the total of 1305, and prepared a multiple choice, 5—response test, Form A. We repeated this process and prepared a second test, Form B. In order to evaluate student progress during the course, we gave Forms A and B as pre-tests; Form A to one-half the group, and Form B, to the other half. As final tests, we gave Form B to those who had taken Form A as a pre-test; and Form A to those who had taken Form B as a pre-test. Table I gives data on the pre- and final tests.

There was a definite mean gain from pre-test to final for each group, and the two test forms, A and B, seem to show equality in evaluating both preliminary and final status. From the viewpoint of evaluation, are we not justified in concluding that a sample of 100 items gives a good general picture of student status involving all 1305 generalizations around which the course was built?

[1] See article by author in *School Review*, "Synthetic Courses in Our Schools and Colleges." September, 1945, pp. 409–12.

TABLE I

COMPARISON OF PRE- AND FINAL TESTS, STUDENTS IN "MAN AND HIS SOCIOLOGICAL AND PSYCHOLOGICAL ENVIRONMENT," MEDICAL COLLEGE OF VIRGINIA

	Pre-test *		Final Test	
	Mean	S.D.	Mean	S.D.
Form A, Pre-test Group.....	52.31	10.88	70.98	9.66
Form B, Pre-test Group.....	50.64	9.66	70.35	6.84

Differences in groups statistically insignificant.
* These groups included a few members of the orientation group not accepted finally.

The four points we wish to stress here are:

1. The statement of course titles in terms of everyday life; and courses organized to accomplish definite functional purposes in life.

2. The feasibility of evaluating student achievement by the use of an adequate random sampling of possible items.

3. Emphasis upon the meaning and significance of principles and generalizations rather than the memorization of mere details.

4. Evaluation of school courses by means of equated preliminary and final achievement tests.

Certain details of methods of instruction in this course have been discussed elsewhere.[2]

[2] Bureau of Educational Research and Service. Medical College of Virginia. *Planning an Instructional Program for Professional Schools*, Richmond 19, Virginia, 1948, pp. viii+154.

ON BALANCING SIMPLE EQUATIONS

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ONE of the topics most commonly disliked by students in freshman inorganic chemistry is equation writing and balancing. This dislike often develops into a complex of fear. It is not uncommon for a student to complete a course in general college chemistry without having learned the fundamentals of equation writing and balancing. It is common knowledge that mastery of balancing equations is acquired only through practice and experience. The inability of students to learn the art of balancing simple equations may be due at least in part to the fact that quite often instructors forget that the "magic" of equation writing is based upon a few simple fundamentals which may appear simple to the instructor and are rushed through so quickly that the average student does not learn or know just what is taking place—to say nothing of being more befuddled later with oxidation-reduction equations.

Most of the present literature [1] deals with various methods of balancing oxidation-reduction equations and very little is to be found on the balancing of simple equations. Wakeham [2] has written an article on the teaching of valence in beginning chemistry. This paper will discuss the teaching of balancing simple equations. By the term simple equation specific reference is made to equations which represent those chemical reactions which are classified as combination, decomposition, simple replacement, and double replacement.

The methods to be described herein may be found in most textbooks on general college chemistry. The order in which the materials are to be taught to give the best results are based on the author's teaching experience. It has been observed that by using these methods students generally lose their "fear" of equation writing and actually develop an enthusiasm for it.

The methods may be divided into three main parts. They are:

1. The teaching of valence.
2. The teaching of formula writing.
3. The teaching of equation writing.

The order in which the above topics are discussed is very important. In most texts the main chapters on valence and formulas usually follow the chapter on equation writing. Most of the difficulty which students may experience in the writing and balancing of equations may be attributed to their not having learned the valences of the elements involved. It is for this reason that an introduction to valence is given before any attempt is made to balance equations. The importance and necessity of *LEARNING* the valence of the most common elements is stressed. It is impossible to write correct formulas without knowing the correct valence of the elements of which the compound is composed. Likewise it is impossible to write and balance equations unless the correct formulas of the compounds in the reaction are known. From this the students should see that unless they learn the valence of the most common elements (which is usually done at first by memory) they will be unable to balance equations.

The Teaching of Valence. Several lecture-recitation periods are devoted to the discussion and to the learning of the valence of the most common elements. It is very helpful to place upon the board a chart which shows the valence of the most common elements and radicals. The elements and radicals are grouped according to their valence and charge. Charts of this type may be found in most college inorganic chemistry texts. At this time no attempt is made to learn the valence of all the elements and radicals. The location of the elements with respect to their valence may be shown on the periodic chart. The elements which are capable of possessing more than one valence are placed in their respective columns. It is sometimes confusing to some students just why a radical such as the sulfate radical has a valence of two while sulfur may have a valence of two, four or six. The use of the structural and/or electronic formulas of the sulfate and similar radicals is generally sufficient to explain why this is so. After the students have learned the valence of the most common elements and radicals, drills should be held and a quiz given on valence. When the valences of the various elements have been learned to the satisfaction of the instructor formula writing is studied.

The Teaching of Formula Writing. In teaching formula writing at first letters instead of symbols are used to represent the various elements.

The charge of the element for which the letter is substituted may be placed either above or at the side of the letter. It is pointed out that elements and radicals of opposite charges (valence) are generally attracted and that the compound which is formed is electrically neutral. Elements which are metals usually possess a positive charge, having as many charges as is represented by their valence. Nonmetals and most radicals are usually negative.

If a monovalent element which is represented by A+ unites with a monovalent element which is represented by B— the compound formed would be represented by the formula A+B— and the compound would be electrically neutral. It is well at this point to tell the students that elements of the same valence but of opposite charges usually unite atom for atom. Thus a divalent element represented by A++ will unite with a divalent element represented by B—— to form the compound A++B—— which is electrically neutral. Other examples may be studied in which the valences of the two reacting elements are not the same. For example if element A which has a positive charge of two should unite with element B which has a negative valence of three it would be necessary to select a least common denominator for the valence number of the two elements which is 2 and 3. The L.C.D. is six. Dividing the charges (valence) of

element A into six give the number three which is placed below the letter A as a subscript in the manner illustrated to give $A{+}{+}_3$. By using the same method for the element represented by B the subscript two is obtained to give $B{-}{-}{-}_2$. The formula which would represent the compound formed by the union of these two elements would be $A{+}{+}_3B{-}{-}{-}_2$. When the charge of each element is multiplied by the subscript it will be found that the compound is electrically neutral. It is important to emphasize here that subscripts affect only the elements which are directly BEFORE them and that subscripts are NOT used after SINGLE elements or Radicals.

When this exercise is mastered the letters are replaced by symbols for the elements to be studied and the above study is repeated. Structural formulas will aid in the study especially when elements of different valence combine. Bogert [3] in his text uses "hooked" formulas to represent the valence of elements. Price and Bruce [4] use the "crisscross" method to unite elements of different valence. A chart similar to the one in the text by Holmes [5] is given to the students to fill in with the correct formulas of the compounds formed by unions of the various elements and radicals. If the chart is constructed large enough the names of the compounds can be placd below them thus affording a review of the nomenclature of compounds. Students should be taught to associate the lower valence of elements with "ous" compounds and the higher valence with "ic" compounds. Much time will be saved by the student if he learns that molecules of most metals are represented by monoatomic formulas. This is also true for most solid elements. The molecules of the "elemental" gases such as oxygen, hydrogen, chlorine and nitrogen are represented by diatonic formulas as O_2 for oxygen and H_2 for hydrogen.

The method of determining the valences of elements from formulas may be studied at this point. Some elements such as oxygen rarely change valence. If the valence of such and similar elements are known (having been memorized) in binary compounds the "unknown" valence of the other elements may be determined. The oxides of nitrogen are excellent examples to use in the illustration and the explanation of this method.

The Oxides of Nitrogen

N_2O
NO
N_2O_3
NO_2
N_2O_5

The formula for nitrous oxide is N_2O. Knowing that the formula for a correct formula must be electrically neutral and that oxygen has a negative valence of negative two, nitrogen must have two positive charges which are distributed between two atoms of nitrogen meaning that each atom must possess a positive valence of one. The alternate method may be used by selecting a L.C.D. which is two. Dividing the subscript by two will give one for nitrogen which represents the valence of nitrogen in nitrous oxide. The other oxides of nitrogen may be used to show that nitrogen may have a valence of two, three, four, and five.

The determination of the valence of radicals or elements in "new" compounds may be found by the recognition of the valence of the "known" element. For example the valence of the perchlorate radical in sodium perchlorate is negative one because one atom of sodium has a positive valence of one and it is united with only one perchlorate radical which would be a negative one. Other example may be selected which will further show the importance of *Knowing* the valence of the most common elements.

The Teaching of Equation Writing. The final step is equation writing and balancing. The students should encounter only the minimum difficulty provided the preceding steps have been learned well. It is good practice to occasionally review the writing of formulas and valence.

The types of chemical reactions are listed and examples of each may be given with word equations. Students should be reminded that skill in balancing equations is *Acquired* only with *PRACTICE* and should be encouraged to practice the writing of those assigned in class and to formulate new ones.

The fundamental principles which must be observed in equation writing are:

1. Classify the type of chemical reaction involved.
2. Write the correct formulas for the reactants and place each, separated by a plus sign on the left side of the arrow. Write the correct formulas of the products of the reaction, each separated by a plus sign, on the right side of the arrow.
3. Balance the equation by placing the *lowest* correct coefficient before the correct formulas in order to have the same number of atoms of the elements on each side of the arrow. This is according to the law of mass action.
4. An equation is balanced only when the correct coefficients have been placed before the CORRECT formulas so that there are the same number of atoms of elements on each side of the arrow. DO NOT BALANCE BY CHANGING FORMULAS.

Students should be taught to recognize the types of chemical reactions in order to know what products will be formed. It is necessary to know what is formed before an equation can be written. The products may be determined by chemical analysis or by reference to similar reactions. Since it is impracticable to analyze each chemical reaction in the laboratory the latter is used along with the "short cuts" which are acquired through experience.

The writing of correct formulas should be emphasized. It is possible to have an equation "Balanced" and it will still be wrong if each formula is not correct. Students are inclined sometimes to make equations balance by changing the subscripts in the formula. This will be minimized if they are instructed to place a "fence" in the form of a rectangle around each correct formula used as described below.

The simple equation for the formation of water by the combination of hydrogen and oxygen under the proper conditions is a good example to use to illustrate the principles involved in equation writing. Even though the average student knows how to write this equation in the balanced form, few have really learned the principles involved well enough to apply them to other reactions.

The students will recognize this reaction as belonging to the class of combination. They should recall that the molecular formula of oxygen and hydrogen are O_2 and H_2 respectively. These are placed on the left side of the arrow and a plus sign is placed between them. Since hydrogen and oxygen are of opposite sign (charges) they will unite two atoms of hydrogen for one atom of oxygen because hydrogen has a valence of positive one while oxygen has a valence of negative two. This will give the equation shown below which has the correct formula but remains unbalanced. It is called a "skeleton" equation.

$$H_2 + O \longrightarrow H_2O$$

Now students are instructed to place a "fence" around each formula in the skeleton equation in the manner shown below: The equation may be balanced by placing the proper coefficients before the formula on the OUTSIDE of the "fence". They may begin to balance the equation by beginning with any compound. Some authors

$$H_2 + O_2 = \rightarrow H_2^{+}O^{=}$$

(Skeleton equation with "fences")

advise to begin with the largest molecule which in this instance is water. By placing the cofficient two before water and two before hydrogen the equation is balanced as is shown below:

$$2H_2^{+} + O^{=} \rightarrow 2H_2^{+}O^{=}$$

Some students will place a subscript two after the oxygen in water in an attempt to balance the equation but this will give a different compound, hydrogen peroxide,

which was not given in the original reaction. The "fence" should remind them NOT TO CHANGE FORMULAS.

More difficult equations may be given in the form of ionic equations if desired. As the students show skill in balancing equations the "fence" and charges may be omitted.

In examples in which some elements may combine to form more than one compound students are cautioned again to associate "ous" compounds with lower valence and "ic" compounds with higher valence. For example iron will combine with chlorine to form ferrous chloride in which iron has a valence of two and the formula is $FeCl_2$. Iron will also combine with chlorine to form ferric chloride in which iron has a valence of three and the formula is $FeCl_3$.

It has been the author's experience in the teaching of inorganic chemistry that even though the steps described above may appear to be very elementary that they are needed by most students. If followed they should aid the students in seeing and in understanding that the first prerequisite in learning to balance equations is the learning of the valence of the most commonly used elements and radicles.

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THE CONCEPT OF OSMOSIS IN GENERAL BIOLOGY

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DIFFUSION through a semipermeable membrane.

The movement of a thin liquid through a semipermeable membrane into a thicker liquid.

Diffusion of substances through a semipermeable membrane.

The diffusion of a solution through a semipermeable membrane.

The passage of two liquids of different densities through a semipermeable membrane.

These definitions of the term osmosis were obtained from five general biology textbooks selected more or less at random from a textbook collection. The five books range from the elementary to the college level and the definitions they contain are agreed on only one point: something passes through a semipermeable membrane.

The purpose here is not to belittle the textbooks or their authors but to emphasize the inadequacy of explanation and inaccuracy of definition that often enters discussions of osmosis. As one of the more important processes in both animal and plant physiology osmosis deserves more consideration than it usually receives. Most of the movements and translocations of raw materials, foods, hormones, enzymes, gases, and waste products within, and in and out of all living organisms are effected largely by means of osmosis.

Because a concise definition is not sufficiently explanatory most textbooks include a discussion with one or more illustrations or experiments in order to explain the phenomenon in greater detail. These discussions ordinarily center around the usual water and water-solution of sucrose

experiments designed to illustrate the process. The conclusion of the discussion is often an extension of the definition found in the glossary and more often than not is somewhat as follows: *Osmosis is the movement of a substance through a semipermeable membrane from the point of lower concentration to the point of higher concentration.*

There is no particular objection to this statement if the discussion makes clear what is meant by lower and higher concentrations. However, the statement is misleading if the purpose of the discussion is to explain *why* the substance moves through the membrane. Compare this statement with the one above: *Osmosis is the movement of a substance through a semipermeable membrane from the point of higher concentration to the point of lower concentration of the substance.*

Consider these two statements in the light of pure water separated from a solution of sucrose in water by a selective membrane permeable to water only. The first statement implies that the substance passes from the point of lower concentration of sucrose to the point of higher concentration of sucrose. It might also be construed as meaning that the two concentrations involved are those of the water. If the statement is referring to the substance that is actually passing through the membrane then it is referring to the concentrations of water and the statement is ambiguous. The second statement, however, leaves no doubt as to what is meant. The concentrations concerned are those of the substance to which the membrane is permeable.

Superficially this definition is the exact opposite of the first and students tend to regard it as being somewhat meaningless when they first encounter it. However, when the explanation is made on the basis of equal volumes of the substances in relation to a fixed area of membrane the statement is clarified. Assume that a membrane permeable to water is separating two equal volumes of pure water at the same temperature. Equal volumes of the water will contain the same number of molecules with the same kinetic energy. Since there are equal numbers of water molecules striking the membrane on both sides with equal intensity and the same rate the water will pass through the membrane in both directions at the same rate. Thus there will be no increase in either volume of water at the expense of the other.

On the other hand if part of the molecules of one of the volumes of water are replaced by molecules of some substance to which the membrane is impermeable a different situation will prevail. In equal volumes of the two substances there will be more water molecules in the pure water than in the water which has been diluted with, say, sucrose. Now if the two are separated by the membrane there will be more molecules of water striking a given area of the membrane on the pure water side than will be striking it on the water-sucrose side. Although water molecules will continue to pass through the membrane in both directions more of them will pass from the pure water side (higher concentration of water) to the water-sucrose side (lower concentration of water) than in the opposite direction. The total volume of the water-sucrose solution will increase as the volume of pure water decreases. With the exception of some charged particles and ions which do not always follow this procedure the above reasoning can readily be applied to cells of both plants and animals.

A simple experiment or demonstration that illustrates the discussion as given is as follows: The upper or wide ends of two thistle tubes are covered with animal membrane permeable to water but impermeable to sucrose. The large end of one tube is filled with pure water and inverted in a beaker of pure water. The large end of the other tube is filled with one molar sucrose solution and inverted in a beaker of pure water. Within several hours the level of the water-sucrose solution will begin to rise and the level of the pure water will remain constant or adjust to the level of water in the beaker.

AN OBJECTIVE TYPE OF ORGANIC CHEMISTRY TEST AND A STUDY OF ITS VALIDITY *

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MANY of the so-called "objective" tests are open to criticism for one or more of the following reasons. Some of them are not truly "objective" in the proper sense of the word. Others, like the true-false type, are sufficiently objective but are considered undesirable by some teachers because of the problem of guessing. A more serious defect, which seems to apply to all types of objective tests, is the difficulty of devising questions that will make the student think and apply his knowledge, rather than to test just his memory by the repetition of factual items. The test described here is the result of an attempt to minimize these defects.

Essentially, the test consists of two parts. One is a series of equations which we have called a "road map" and the other is a numbered list of names to accompany the road map. Molecular formulas with interconnecting arrows are given for the equations with conditions indicated where desired. The arrangement is very similar to the one described by Phipps.[1] An example of such a series of interrelated equations is shown in Figure 1. It should be noted that there are several places at

* Presented as part of a Chemical Education Symposium on "The Training of a Chemist" at the Southwest Regional Meeting of the American Chemical Society, Shreveport, La., December 10, 1948.

[1] Phipps, H. E., *Journal of Chemical Education*, 14:129 (1937).

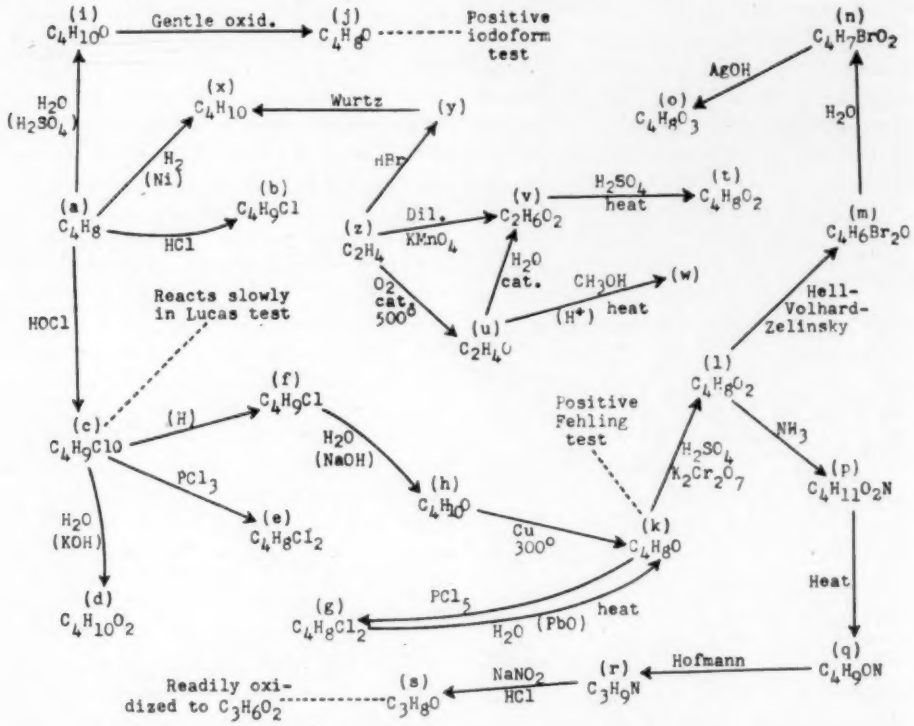

Figure 1.

which the student may start. For example, (z) is obviously the formula for ethylene and (y) at once becomes identified as ethyl bromide; (j) may be identified from the mode of formation and the reaction it undergoes. Likewise (s) is readily seen to be n-propyl alcohol. In the case of (k) complete identification cannot be made from the immediately adjoining reactions, but the possibilities can be narrowed down to either butanal or 2-methylpropanal, and then an examination of the related compounds on the road map shows it to be the former. Thus, from several possible starting points, the student may follow the reactions and work out the rest of the road map. If it appears that the use of the molecular formula makes the answer too obvious, the empirical formula may be used (such as $(CH_2O)_x$ for acetic acid), or the formula may be omitted entirely, as in the case of (y). The conditions for the reactions may be indicated more or less specifically, depending on how much of this information one wishes the student to furnish. For example, the conditions for the reaction from (p) to (q) were deliberately left somewhat indefinite by merely specifying "heat".

Arranging the question in the form of the road map just described does not make the test objective if the answer is to be in the form of equations written by the student. Grading is no easier than with ordinary questions. Even if the answer is merely a list of formulas, as suggested by Phipps,[1] the paper has to be carefully read and legitimate irregularities may still exist which make judgment necessary in the grading process. Such a test is not truly objective. The naming of butane illustrates this point. Butane is the correct I.U.C. name for the normal compound, yet in common terms there are two isomeric butanes. Thus the student who writes "butane" for normal butane is not incorrect, but the student who writes "n-butane" shows more specifically that he knows the correct answer. The description of conditions offers another example of possible ambiguities. In indicating the conditions for the formation of acetone from calcium acetate, five well known textbooks give the following: "heat", "heated strongly", "dry distillation", "300–500°", "about 400°". None are incorrect, but if these occurred as answers in an examination, there might be some question as to how much credit each should be allowed. To eliminate the possibility of such irregularities the practice of giving a numbered list of the names of all the compounds that occur in the road map was adopted (Table I). Accompanying the list is a column of letters with a blank space beside each. The student then decides on the name for a compound in the road map, finds this name in the list, and puts the corresponding number in the blank beside the appropriate letter. (In Table I the blanks have been filled with the correct answers.) For the convenience of the student, the road map and the list are placed face to face when the examination is stapled together. Actually, more names than just those of the correct compounds are listed. In most cases one or more isomers are included so that the student must make considerable use of his chemical knowledge in choosing from the list. The student must know not only the formulas for the compounds, but he must know the names as well. The teacher may use the systematic I.U.C. names, common names, or some of each, depending on which he wishes to stress.

The compound 2-methylpropanal has been deliberately omitted from the list in order to illustrate how the difficulty of the test may be varied. For example, in giving the test shown here, the students could be told that all compounds appearing on the road map are included in the list. Then the omission of the isomers of a compound (as in the case of butanal) makes it easier for the student. As greater difficulty is desired, more isomers may be added to the list. If, due to lack of isomers, the test still seems to be too easy, then the class is told that all of the compounds may or may not be listed. In this case one more

TABLE I

ROAD MAP LIST

1. Acetaldehyde	48. Diethyl ether	a. 27
2. 1-Amino-2-butanone	49. 2,3-Dihydroxybutanal	
3. 3-Amino-2-butanone	50. 2,4-Dihydroxybutanal	b. 35
4. 4-Amino-2-butanone	51. 3,4-Dihydroxybutanal	
5. α-Aminobutyraldehyde	52. 1,3-Dihydroxy-2-butanone	c. 36
6. β-Aminobutyraldehyde	53. 1,4-Dihydroxy-2-butanone	
7. γ-Aminobutyraldehyde	54. 3,4-Dihydroxy-2-butanone	d. 21
8. Ammonium butyrate	55. 2,3-Dihydroxy-2-methylpropanal	
9. Ammonium isobutyrate	56. 1,3-Dioxane	e. 43
10. α-Bromobutyric acid	57. 1,4-Dioxane	
11. β-Bromobutyric acid	58. Ethyl bromide	f. 34
12. γ-Bromobutyric acid	59. Ethylene	
13. α-Bromobutyryl bromide	60. Ethylene glycol	g. 42
14. β-Bromobutyryl bromide	61. Ethylene oxide	
15. γ-Bromobutyryl bromide	62. 2-Hydroxybutanal	h. 29
16. α-Bromoisobutyric acid	63. 3-Hydroxybutanal	
17. β-Bromoisobutyric acid	64. 4-Hydroxybutanal	i. 30
18. γ-Bromoisobutyryl bromide	65. 1-Hydroxy-2-butanone	
19. β-Bromoisobutyryl bromide	66. 3-Hydroxy-2-butanone	j. 26
20. Butanal	67. 4-Hydroxy-2-butanone	
21. 1,2-Butandiol	68. α-Hydroxybutyric acid	k. 20
22. 2,3-Butandiol	69. β-Hydroxybutyric acid	
23. 1,3-Butandiol	70. γ-Hydroxybutyric acid	l. 33
24. 1,4-Butandiol	71. 2-Hydroxy-2-methylpropanal	
25. n-Butane	72. 3-Hydroxy-2-methylpropanal	m. 15
26. 2-Butanone	73. α-Hydroxyisobutyric acid	
27. 1-Butene	74. β-Hydroxyisobutyric acid	n. 10
28. 2-Butene	75. 2-Hydroxypropanal	
29. n-Butyl alcohol	76. 3-Hydroxypropanal	o. 68
30. sec-Butyl alcohol	77. Isobutane	
31. tert-Butyl alcohol	78. Isobutyl alcohol	p. 8
32. n-Butyramide	79. Isobutyramide	
33. n-Butyric acid	80. Isobutyric acid	q. 32
34. 1-Chlorobutane	81. Isopropyl alcohol	
35. 2-Chlorobutane	82. Isopropylamine	r. 91
36. 1-Chloro-2-butanol	83. Methyl cellosolve	
37. 3-Chloro-2-butanol	84. Methylethylamine	s. 90
38. 4-Chloro-2-butanol	85. Methyl isopropyl ether	
39. 2-Chloro-1-butanol	86. 2-Methyl-1,2-propandiol	t. 57
40. 3-Chloro-1-butanol	87. 2-Methylpropanoic acid	
41. 4-Chloro-1-butanol	88. 2-Methylpropene	u. 61
42. 1,1-Dichlorobutane	89. Methyl n-propyl ether	
43. 1,2-Dichlorobutane	90. n-Propyl alcohol	v. 60
44. 1,3-Dichlorobutane	91. n-Propylamine	
45. 1,4-Dichlorobutane	92. Propylene glycol	w. 83
46. 2,2-Dichlorobutane	93. Tetramethylene glycol	
47. 2,3-Dichlorobutane	94. Trimethylamine	x. 25
	95. Trimethylene glycol	
		y. 58
		z. 59

number is added to the list with the words "not listed". Thus, if a name actually has been omitted, the student may write in the proper number for "not listed" and get full credit. No credit is given for a space left blank. If desired, two or more names for the same compound may be included, but unless such duplication is limited to the compounds that are not on the road map. the test is no longer one in which there is only one correct answer for each blank.

A variation that suggests itself, though it has not been tried by the author, is to list key physical properties or special uses that would identify the compound, instead of the name. Or a descriptive word (or

phrase) might be put in the road map instead of the formula. This could scarcely be done for the whole list, but for such compounds as ethylene glycol, diethyl ether, ethyl alcohol, carbon tetrachloride, methane, formaldehyle and methylene iodide suitable characterizations could easily be devised. One might list the structural formulas of the compounds instead of the names, but this would give no idea of the students' ability in nomenclature and it would be more difficult to set up for mimeographing.

A simplified road map is shown in Figure 2 to illustrate how the test may be adapted to less advanced students. Not only are structural formulas used instead

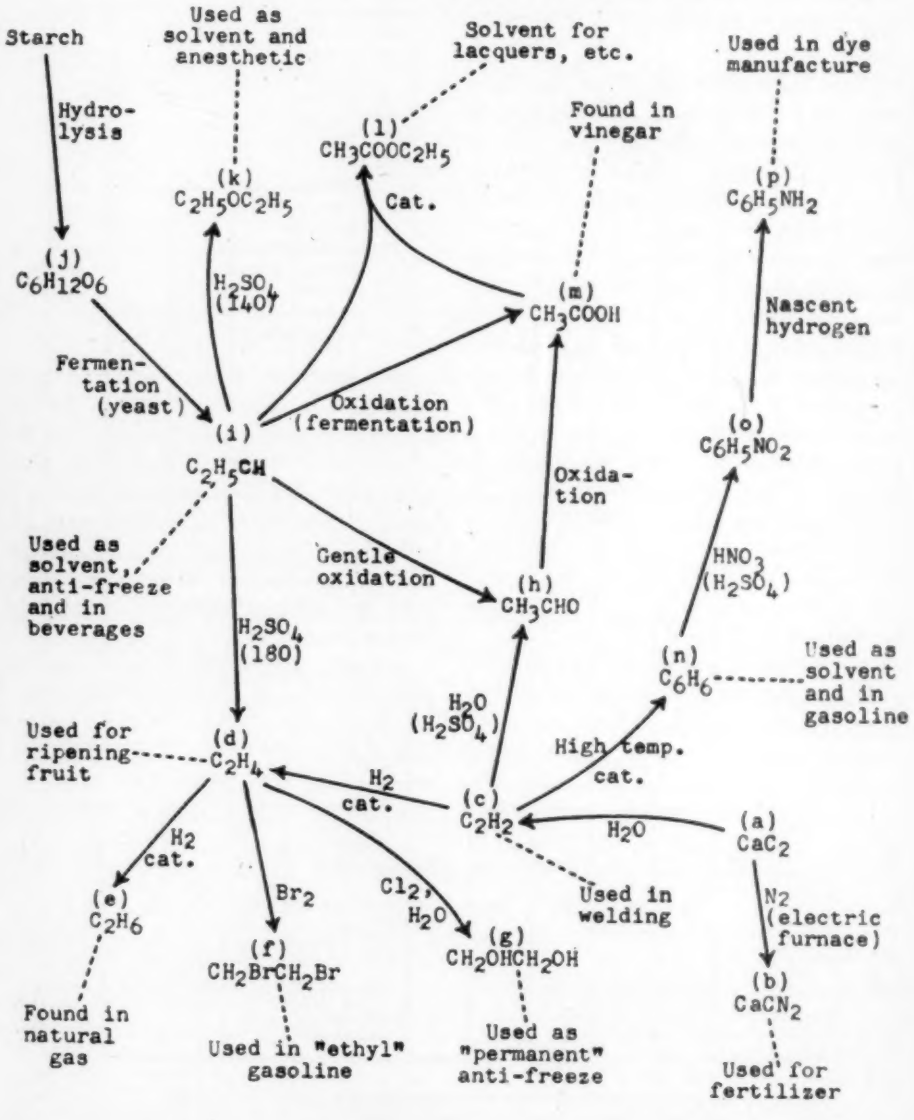

Figure 2.

of molecular formulas, but characteristic uses of many of the compounds are given to aid the student in identifying them. Thus it could be used for the organic part of a beginning course in general college chemistry, or even for a high school chemistry course. This road map is based on the material presented in the high school text by Charles E. Dull—"Modern Chemistry". (Henry Holt and Company, New York). All of the compounds listed are included in the book and all but two of the reactions are mentioned. It is equally suitable for use with "Chemistry and You", a textbook for high schools by Hopkins, Smith, Davis, McGill and Bradbury (Lyons and Carnahan, Chicago). The test is further simplified by including in the road map list, shown in Table II, only the compounds to be found on the road map itself. This particular test has not been used by the author and is offered here merely as a suggestion. The individual teacher could make many variations depending on the compounds studied and the emphasis placed on their properties and uses. It could easily be made more difficult by changing one or more of the structural formulas to molecular formulas, or by adding more compounds to the list as in the case shown in Table I.

A road map based on the derivatives of methane might be used in conjunction with the texts mentioned above. Among others, the following compounds could be included: methane, chloromethane, methylene chloride, chloroform, carbon tetrachloride, methanol, formic acid, formaldehyde and carbon dioxide. If desired, the list might be extended to include phosgene, carbon monoxide and urea. (Additional identification of the latter compound could include a reference to its use in dentifrices!)

TABLE II

ROAD MAP LIST

1. Acetaldehyde	a. ———
2. Acetic acid	b. ———
3. Acetylene	c. ———
4. Aniline	d. ———
5. Benzene	e. ———
6. Calcium carbide	f. ———
7. Calcium cyanamide	g. ———
8. Ethane	h. ———
9. Ethanol	i. ———
10. Ethyl acetate	j. ———
11. Ethylene	k. ———
12. Ethylene dibromide	l. ———
13. Ethylene glycol	m. ———
14. Ethyl ether	n. ———
15. Glucose	o. ———
16. Nitrobenzene	p. ———

The same type of test might be used to advantage in inorganic chemistry, particularly for an element like nitrogen. In this case the road map could include the nitrogen cycle with the various processes of nitrogen fixation, the preparation and properties of the oxides and acids of nitrogen, and the manufacture of fertilizers, explosives and selected nitrogen-containing organic compounds.

Students (and teachers also) are too prone to separate knowledge into isolated compartments, just as a book is divided into chapters. The road map test could be organized to help break down these artificial barriers. For example, in the usual

TABLE III

CORRELATIONS OF ROAD MAPS WITH OTHER TESTS

No.	Tests Correlated	Number of Students	Correlation Coefficient	Probability of Chance Occurrence
1.	Final road map vs. rest of final	19	0.501	1.7%
2.	Final road map vs. rest of final	26	0.773	0.0057
3.	Average of three road maps vs. average of eight quizzes	26	0.846	0.0012
4.	Final road map vs. rest of final	50	0.577	0.0028
5.	Average of two road maps vs. average of ten quizzes	50	0.667	0.00017
6.	Average of two road maps vs. average of two 1-hour examinations	50	0.732	0.000025
7.	Final road map vs. part one of final	50	0.689	0.000093

chemistry course ammonia and the carbonates are taken up at different times and considered quite independently, yet limestone is used in making calcium cyanamide for the manufacture of ammonia and calcium carbonate is one of the products of hydrolysis of the cyanamide. Also, ammonia is used in the Solvay process for the manufacture of sodium bicarbonate, and ammonia and carbon dioxide are the raw materials in the manufacture of synthetic urea. Ammonium carbonate is used as "smelling salts" and in fire extinguishing preparations. There are many other cases of these inter-relationships that could be emphasized by the use of a road map.

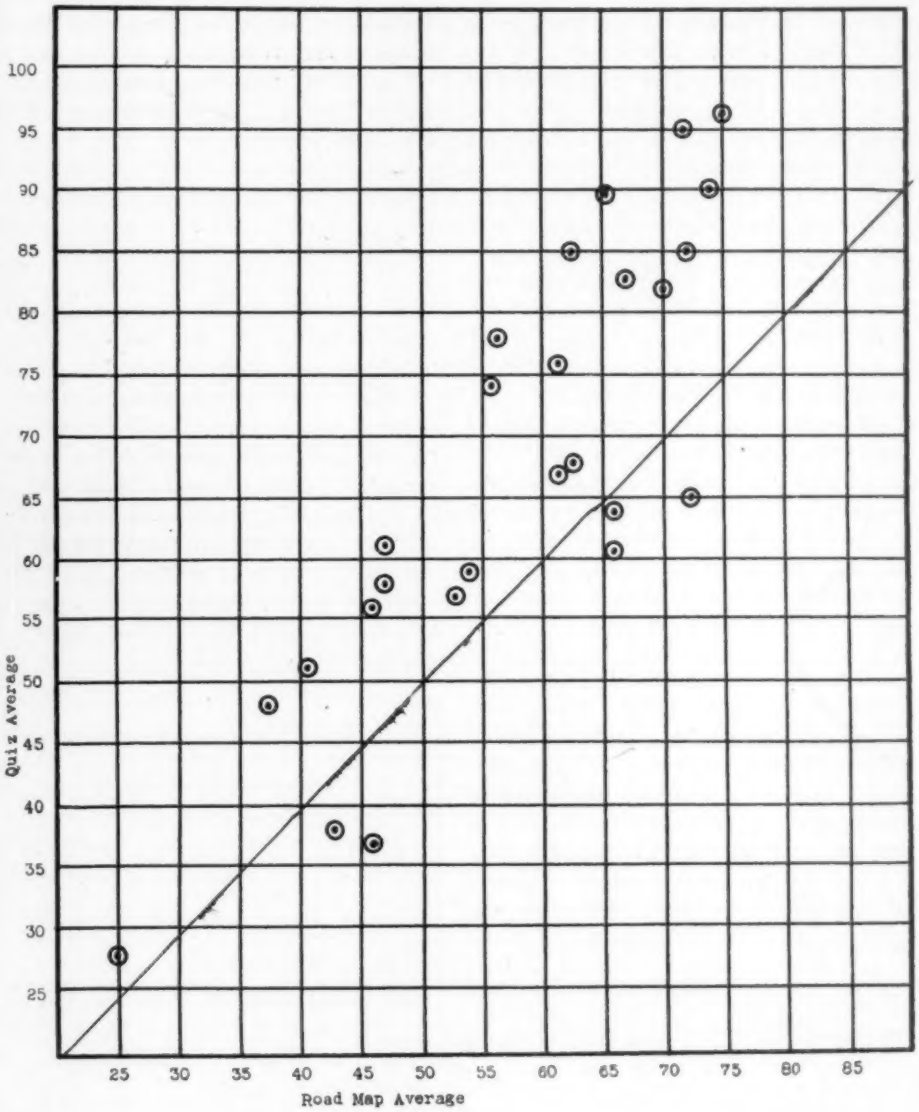

Figure 3

The question very properly arises: "Does this examination test the student's knowledge of organic chemistry, or is it a psychological test of his ability to decipher a puzzle?" To answer this question, correlation studies were made. The students' ranks in the class on the basis of the road map grades were correlated with their ranks from other types of testing procedures. The correlation coefficients given in Table III were calculated using the Spearman ranks formula.[2] It should be noted that with the exception of the first one, all of the coefficients are high enough to be quite satisfactory. Grades from eight different road maps were used in calculating the various coefficients. From the standpoint of sound statistical procedure, a correlation based on several tests (as in the case for Nos. 3, 5, and 6) is more reliable. When two parts of the same examination are correlated (as in Nos. 1, 2, and 4), then the relation of the total length of the test to the time allowed becomes a considerable factor. That is, if the students do not have time to finish the whole examination, then one part may be completed while another part is neglected, and the correlation is accordingly less. This is not so much of a problem in final examinations lasting three or four hours, but for one-hour examinations in which the student is rushed for time, the correlation coefficient has been found to be lower. No. 7 in the table is a special case in respect to the time element. The correlation is between two parts of the same final examination, given on the same morning, but the whole examination time was divided into two periods and the two parts of the examination were handed in separately. In this way one part was not neglected in order to answer the other and the resulting correlation is quite favorable. Likewise, if the average of the road map grades is correlated against grades from tests which do not include road maps, the correlation is reasonably good, as indicated in the table. The column headed "probability of chance occurrence" gives the probability of obtaining the correlation coefficient given, if the actual correlation between the two sets of grades were zero.

The table represents data from four different classes. By coincidence two of these each had 50 students.

Case No. 3 in Table III is illustrated graphically by the scattergram shown in Fig. 3.

[2] The correlation coefficient, $r = 1 - \frac{6\,d^2}{N(N^2-1)}$, where d is the difference in rank and N is the number of students.

SUMMARY

A matching type of objective test for organic chemistry is described which, it is believed, requires the student to do some thinking as well as the memorizing of facts. It is not very difficult to make up, is very easy to grade, and covers a considerable amount of subject matter. Examples of the test are given. Correlation studies indicate that it is comparable in its validity to the usual testing procedures. It is not suggested as a complete testing program but as a supplement to other types of questions.

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HIGH SCHOOL SCIENCE EXPERIENCES OF 506 NON-SCIENCE CURRICULA COLLEGE STUDENTS

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SAN FRANCISCO State College has undertaken a complete revision of its basic requirements for the A.B. degree.

The Natural Science Division, as part of its study of the revision of their requirements, wished to have some idea of the high school science experiences of the non-science curricula college students. Therefore, in the fall of 1947, students in the science courses most frequently taken by non-science students were surveyed as to their high school science background.

Three sections of a first semester course in General Biology, two sections of a second semester General Physical Science, and one section of a third semester General Physical Science class were used in the study. A total of 506 students were included.

The instructor wrote on the blackboard the following:

"Courses taken in high school during the 9th, 10th, 11th, 12th grades:

General Science	Physiology
Biology	Chemistry
General Physical Science	Physics

Other science courses

"Please indicate the length of the course in terms of one half year, year, year and a half, two years."

Duplication was eliminated by excusing from the class any student who was in a prior class included in the study. The survey was conducted on the same day or adjacent days in all classes included. The students were requested to hand in the names of their high school science courses and the respective length of each course on a standard size sheet of paper. Signatures were not required and the purpose of the study was explained.

The data were assembled in a series of tables so arranged that cross checking would indicate any errors of recording. Fourteen tables were developed.

It is realized that a student response study is subject to errors, but there was not time nor funds for a survey of high school transcripts. It is believed that the number of cases, the reason for the study, and the fact that no signatures were required eliminated all reasons for intentional false reports and that the results have reasonable validity.

The first tabulation was the listing of high school science courses by the frequency of their occurrence.

TABLE I

FREQUENCY OF HIGH SCHOOL SCIENCE COURSES IN 506 CASES OF NON-SCIENCE CURRICULA COLLEGE STUDENTS

Course	No.	Per cent
Chemistry	288	56.9
Biology	227	44.8
Gen. Science	190	37.5
Physics	146	28.8
Physiology	123	24.3
General Phys. Science	19	3.75
Botany	8	1.58
Zoology	3	0.59
Astronomy	3	0.59
Aeronautics	2	0.40
Biol. of Flight	2	0.40
Chem. of Foods	2	0.40
Earth Science	2	0.40
Geology	2	0.40
Phys. Geog.	2	0.40
Pre-Flight Aero.	2	0.40
Agricultural Science	1	0.20
Aviation Science	1	0.20
Elem. Elect.	1	0.20
Floriculture	1	0.20
Horticultural Science	1	0.20
Industrial Science	1	0.20
Totals	506	100

The results were somewhat surprising since it is generally assumed that non-science curricula students meet their high school science requirement by taking biology. Chemistry was the most frequent listed, 288 cases (56.9 per cent), biology second with 227 cases (44.8 per cent), then General Science 190 cases (37.5 per cent), Physics 146 cases (28.8 per cent) and General Physical Science 19 cases (3.75

per cent). Sixteen other science courses were listed with the frequencies shown in Table I. The General Science data are probably not indicative of the true number of students taking this subject because many students have it in the seventh or eighth grade. This study called for the science taken in the ninth, tenth, and other high school years. It was felt that science taken before the high school years could be discounted as an indication of any need for college science offerings. It is realized that the same statement might be made for science taken during the ninth and tenth years and in many cases even for science in the last two years of high school. Unreported studies of student success in our general physical science courses indicate that the only group standing above the other groups in points earned were those students having both chemistry and physics in high school. This might well be due to the quality of the student rather than to the high school experience. This study was based on the science in a standard four year high school so all science courses taken during these years were included.

The number of high school science courses taken by an individual student are shown in Table II.

TABLE II

NUMBER OF HIGH SCHOOL SCIENCE COURSES TAKEN BY AN INDIVIDUAL STUDENT

Number of Courses	Number of Students	Per cent
None	13	2.57
One	152	30.04
Two	191	37.74
Three	115	22.72
Four	28	5.53
Five	6	1.19
Six	1	0.20
Totals	506	100

Thirteen (2.57 per cent) reported no science courses, 152 (30.04 per cent) reported one, 191 (37.74 per cent) two and 115 (22.72 per cent) three. Others reported four, five, and six courses. Most of those with more than three courses had one semester courses or one semester of a year course.

Most of the students at San Francisco State College come from the local Bay Area. In the Fall of 1947 the percentage distribution of the students at San Francisco State College was, according to counties:

City and County of San Francisco	57.5%
Alameda County	24.5%
Contra Costa County	5.4%
Marin County	2.1%
San Mateo County	2.0%
Santa Clara County	0.6%
Total Bay Area Counties	92.1%

The majority of these students come from city high schools; San Francisco, Oakland, Berkeley, Alameda, Richmond, and South San Francisco. Although the California State requirements for high school graduation contain no science requirement, some of the counties such as San Francisco require two semesters in one laboratory science. The 2.6 per cent who reported no ninth to twelfth grade science could be from the smaller high schools in other counties. Thirty-one counties outside the Bay Area were represented in our 3,000 student body in the Fall of 1947 as well as a good representation (2.1 per cent) from other states, and from foreign countries (0.7 per cent).

Tables III, IV, V, and VI contain the data on the nature of the science work taken by the students with one, two, three, or more than three high school science courses respectively.

TABLE III

DISTRIBUTION OF HIGH SCHOOL SCIENCE COURSES FOR 152 STUDENTS WITH ONE COURSE

Courses	No.	Per cent
Chemistry	55	36.20
Biology	46	30.23
Physiology	26	17.10
Gen. Science	12	7.90
Physics	8	5.26
Gen. Phys. Science	2	1.32
Chem. of Foods	1	0.66
Earth Science	1	0.66
Industrial Science	1	0.66

Chemistry led with 55 (36.20 per cent) of the 152 students having one course. Biology was second with 46 (30.23 per cent), physiology third with 26 (17.10 per cent), then General Science 12 (7.90 per cent), physics 8 (5.26 per cent), and General Physical Science 2 (1.32 per cent). Three other courses were listed by one student each. (Table III.)

The leading pair of courses taken by students was chemistry—physics with 46 (24.08 per cent) out of the 191 students having two courses. The biology-chemistry combination was second with 33 (17.28 per cent), then biology-general science and chemistry-general science each with 24 (12.57 per cent) of the total. General Science-physiology had 17 (8.90 per cent) and chemistry-physiology 14 (7.34 per cent) students. Other pairs of courses had lower frequency as recorded in Table IV. The high rank of the chemistry-physics combination is surprising in a group of non-science curricula college students. This may be due to our require-

TABLE IV

DISTRIBUTION OF HIGH SCHOOL SCIENCE COURSES FOR 191 STUDENTS WITH TWO COURSES

Courses	No.	Per cent
Chemistry—Physics	46	24.08
Biology—Chemistry	33	17.28
Biology—Gen. Sci.	24	12.57
Chemistry—Gen. Sci.	24	12.57
Gen. Sci.—Physiology	17	8.90
Chemistry—Physiology	14	7.34
Biology—Physics	8	4.19
Biology—Physiology	5	2.62
Gen. Sci.—Physics	4	2.09
Biology—Botany	3	1.57
Physics—Physiology	3	1.57
Biology—Gen. Phys. Sci.	2	1.05
Gen. Phys. Sci.—Physiology	2	1.05
Biology—Chem. of Foods	1	0.52
Chemistry—Botany	1	0.52
Gen. Sci.—Agric. Sci.	1	0.52
Gen. Sci.—Botany	1	0.52
Gen. Sci.—Gen. Phys. Sci.	1	0.52
Physics—Botany	1	0.52

TABLE V

DISTRIBUTION OF HIGH SCHOOL SCIENCE COURSES FOR 115 STUDENTS WITH THREE COURSES

Courses	No.	Per cent
Biology—Chem.—Gen. Sci.	22	19.1
Gen. Sci.—Chem.—Physics	22	19.1
Biology—Chem.—Physics	14	12.2
Biology—Chem.—Physiology	11	9.56
Biology—Gen. Sci.—Physiol.	10	8.70
Biology—Gen.Sci.—Physics	8	6.96
Gen. Sci.—Chem.—Physiology	7	6.08
Biology — Gen. Phys. Sci. — Physiol.	5	4.35
Chem.—Physics—Physiol.	4	3.48
Biology—Physics—Physiol.	2	1.74
Biology—Chem.—Zoology	1	0.87
Biology—Chem.—Biol. of Flight *	1	0.87
Biology—Gen. Sci.—Gen. Phys. Sci.	1	0.87
Biol.—Phys.—Phys. Geog.	1	0.87
Gen. Sci.—Physiology.—Astro.	1	0.87
Gen. Sci.—Physiol.—Physics	1	0.87
Gen. Sci.—Chem.—Elem. Elect.	1	0.87
Gen. Sci. — Chem. — Pre Flight Aviation *	1	0.87
Gen. Sci.—Physics—Aviat. Sci.	1	0.87
Physiol.—Floriculture—Horticulture Sci.*	1	0.87

* One semester.

TABLE VI

DISTRIBUTIONS OF HIGH SCHOOL SCIENCE COURSES FOR 35 STUDENTS WITH MORE THAN THREE COURSES

Courses	No.	Per cent
Biol.—Gen. Sci.—Chem.—Physics	13	37.1
Biol.—Gen. Sci.—Chem.—Physiology	6	17.14
Biol.— Gen. Sci.— Chem.— Gen. P.S.	1	2.86
Biol. — Gen. Sci. — Gen. P.S. — Physiol.	1	2.86
Biol.—Gen. Sci.— Physics — Pre Flight Aeronautics*	1	2.86
Biol.—Gen. P.S.—Chem.—Physics	1	2.86
Biol.—Chem.— Physics—Geology	1	2.86
Biol. — Chem. — Botany — Aeronautics	1	2.86
Chem. — Gen. Sci. — Physics — Physiol.	1	2.86
Chem.—Gen. Sci.—Gen. P.S.—Physics	1	2.86
Chem. — Gen. Sci. — Physics — Earth Sci.	1	2.86
Biol.—G.S.*—G.P.S.*—Chem.*—Physiol.*	1	2.86
Biol.—G.S.—G.P.S.*— Physics—Physiol.	1	2.86
Biol.—G.S.—Chem.— Physics *—Physiol.*	1	2.86
Biol. — G.S. — Chem. — Biol. of Flight—Aeronautics*	1	2.86
Gen. Sci. — Physics — Physiol. — Phys. Geog.—Astronomy	1	2.86
Chem.*— Physics *— Physiol.*—Bot.*—Zool.*	1	2.86
Gen. Sci. — Chem. — Physics — Astronomy—Geology—Zool.	1	2.86

* One semester.

ment of at least one course in the biological sciences for all chemistry or physical science majors and minors. Some of them take the lecture-demonstration general biology course used in this study in spite of our recommendation to elect laboratory courses in bacteriology or physiology as being more usefully related to chemical and physical science work. The emphasis on chemistry and physics during the war years may have been a factor in the frequency of this combination.

The combinations of biology-chemistry-general science and general science-chemistry-physics are tied for first among students taking three courses with 22 (19.1 per cent) of the 115 such students for each triad. Biology-chemistry-physics with 14 (12.2 per cent), biology-chemistry-physiology with 11 (9.56 per cent), biology-general science-physiology with 10 (8.70 per cent), biology-general science-physics with 8 (6.96 per cent), and general science-chemistry-physiology with 7 (6.08 per cent) rank in that order. Other combinations are presented in Table V.

Two combinations of three courses were used by more than one of the 35 students in this category; biology-general science-chemistry-physics led with 13.) 37.1 per cent) of the 35 and biology-general science-chemistry-physiology with 6 (17.14 per cent). Sixteen other combinations are listed in Table VI. G.S. is general science and G.P.S. is general physical science.

TABLE VII

COMBINATIONS OF CHEMISTRY WITH OTHER HIGH SCHOOL SCIENCE COURSES

Combination	No.	Per cent
Chemistry only	55	19.11
Chemistry—Physics	46	15.98
Chemistry—Biology	33	11.49
Chemistry—Gen. Sci.	24	8.34
Chem.—Gen. Sci.—Biol.	22	7.64
Chem.—Gen. Sci.—Physics	22	7.64
Chem.—Physiology	14	4.86
Chem.—Biol.—Physics	14	4.86
Chem.—Gen. Sci.—Biol.—Physics	13	4.52
Chem.—Biol.—Physiology	11	3.82
Chem.—Gen. Sci.—Physiology	7	2.43
Chem.—G.S.—Biol.—Physiology	6	2.08
Chem.—Physics—Physiology	4	1.39
Chem.—Botany	1	0.35
Chem.—Biol.—Zoology	1	0.35
Chem.—Biol.—Biol. of Flight*	1	0.35
Chem.—Gen. Sci.—Elem. Elect.	1	0.35
Chem.—Gen. Sci.—Pre Flight Aero.*	1	0.35
Chem.—Biol.—G.S.—G.P.S.	1	0.35
Chem.—Biol.—G.P.S.—Physics	1	0.35
Chem.—Biol.—Physics—Geol.	1	0.35
Chem.—Gen. Sci.—Physics—Physiol.	1	0.35
Chem.—G.S.—Physics—Earth Sci.	1	0.35
Chem.—G.S.—G.P.S.—Physics	1	0.35
Chem.—Biol.—Bot.—Aeronautics	1	0.35
Chem. with 4 other courses	4	1.39
Chem. with 5 other courses	1	0.35
Total	288	100

* One semester.

TABLE VIII

COMBINATIONS OF BIOLOGY WITH OTHER HIGH SCHOOL SCIENCE COURSES

Combination	No.	Per cent
Biology only	46	20.26
Biology—Chem.	33	14.52
Biology—Gen. Sci.	24	10.58
Biol.—Gen. Sci.—Chem.	22	9.69
Biol.—Chem.—Physics	13	5.73
Biol.—Gen. Sci.—Chem.—Physics	13	5.73
Biol.—Chem.—Physiol	11	4.85
Biol.—Gen. Sci.—Physiol.	10	4.40
Biol.—Physics	8	3.52
Biol.—Gen. Sci.—Physics	8	3.52
Biol.—Gen. Sci.—Chem.—Physiol.	6	2.64
Biol.—Gen. P.S.—Physiology	5	2.2
Biol.—Physiology	5	2.2
Biol.—Botany	3	1.32
Biol.—Gen. Phys. Sci.	2	0.88
Biol.—Physics—Physiology	2	0.88
Biol.—Chemistry of Foods	1	0.44
Biol.—Gen. Sci.—Physics	1	0.44
Biol.—Chem.—Biol. of Flight*	1	0.44
Biol.—Chem.—Zoology	1	0.44
Biol.—Physiol.—Phys. Geog.	1	0.44
Biol.—G.S.—G.P.S.—Chem.	1	0.44
Biol.—G.P.S.—Chem.—Physics	1	0.44
Biol.—Chem.—Physics—Geol.	1	0.44
Biol.—G.S.—G.P.S.—Physiology	1	0.44
Biol.—G.S.—Physics—Pre Flight Aeronautics*	1	0.44
Biol.—Chem.—Bot.—Aeronautics	1	0.44
Biol.—Chem.—Physics—Hygiene	1	0.44
Biol.—G.S.—G.P.S.—Chem.—Physiol.	1	0.44
Biol.—G.S.—Chem.—Physics—Physiol.	1	0.44
Biol.—G.S.—G.P.S.—Physics—Physiol.	1	0.44
Biol.—G.S.—Chem.—Biol. Flight—Aeronautics	1	0.44
Total	227	100

* One semester.

It seemed desirable to study the combinations of the more commonly used science courses with other science studies. Tables were constructed for the combinations of sciences with the six most frequently occurring courses: chemistry (Table VII), biology (Table VIII), General Science (Table IX), Physics (Table X), Physiology (Table XI), and General Physical Science (Table XII).

The percentages stated in these tables are the percentage of the total number of students having taken the key course. For example in Table VII, Combinations of Chemistry with other High School Science courses: (a) the number of students taking only chemistry was 55 or 19.11 per cent of the 288 students reporting chemistry among their high school experience; (b) chemistry and physics were reported by 46

TABLE IX

COMBINATIONS OF GENERAL SCIENCE WITH OTHER HIGH SCHOOL SCIENCE COURSES

Combination	No.	Per cent
General Science only	12	6.31
Gen. Sci.—Biology	24	12.63
Gen. Sci.—Chem.	24	12.63
Gen. Sci.—Biol.—Chem.	22	11.6
Gen. Sci.—Chem.—Physics	22	11.6
Gen. Sci.—Physiology	17	8.95
Gen. Sci.—Biol.—Chem.—Physics	13	6.84
Gen. Sci.—Biol.—Physiology	10	5.26
Gen. Sci.—Biol.—Physics	8	4.21
Gen. Sci.—Chem.—Physiology	7	3.68
Gen. Sci.—Biol.—Chem.—Physiology	6	3.16
Gen. Sci.—Physics	4	2.11
Gen. Sci.—Gen. Phys. Sci.	1	.526
Gen. Sci.—Botany	1	.526
Gen. Sci.—Agricultural Sci.	1	.526
Gen. Sci.—G.P.S.—Biol.	1	.526
Gen. Sci.—Physics—Physiol.	1	.526
Gen. Sci.—Chem.—Elem. Elect.	1	.526
Gen. Sci.—Physiol.—Astron.	1	.526
Gen. Sci.—Physics—Aviation Sci.	1	.526
Gen. Sci.—Chem.—Pre Fli. Aero	1	.526
G.S.—Biol—G.P.S.—Chem.	1	.526
G.S.—Biol.—G.P.S—Physiol.	1	.526
G.S.—Chem.—Physics—Physiol.	1	.526
G.S.—Chem.—Physics—Earth Sci.	1	.526
G.S.—G.P.S.—Chem.—Physics	1	.526
G.S.—Biol.—Physics—Pre Fli. Aero.	1	.526
G.S. and 4 other courses	5	2.63
G.S. and 5 other courses	1	.526
Total	190	100

TABLE X

COMBINATIONS OF PHYSICS WITH OTHER HIGH SCHOOL SCIENCE COURSES

Combinations	No.	Per cent
Physics only	8	5.48
Physics—Chem.	46	31.50
Physics—Gen. Sci.—Chem.	22	15.07
Physics.—Chem.—Biol.	14	9.60
Physics—Chem.—Biol.—G.S.	13	8.90
Physics—Biology	8	5.48
Physics—Biol.—G.S.	8	5.48
Physics—Gen. Sci.	4	2.74
Physics—Chem.—Physiol.	4	2.74
Physics—Physiology	3	2.06
Physics—Biol.—Physiology	2	1.37
Physics—Botany	1	.685
Physics—Gen. Sci.—Physiol.	1	.685
Physics—Gen. Sci.—Aviation Sci.	1	.685
Physics—G.P.S.—Biol.—Chem.	1	.685
Physics—Biol.—Chem.—Geol.	1	.685
Physics—G.S.—Chem.—Physiol.	1	.685
Physics—G.S.—Chem.—Earth Sci.	1	.685
Physics—G.S.—G.P.S.—Chem.	1	.685
Physics—G.S.—Biol.—Pre Flight Aeronautics *	1	.685
Physics and 4 other sciences	4	2.74
Physics and 5 other sciences	1	.685
Total	146	100

* One semester.

TABLE XI

COMBINATIONS OF PHYSIOLOGY WITH OTHER HIGH SCHOOL SCIENCE COURSES

Combinations	No.	Per cent
Physiology only	26	21.10
Physiol.—Gen. Sci.	17	13.81
Physiol.—Chem.	14	11.38
Physiol.—Biol.—Chem.	11	8.94
Physiol.—Biol.—Gen. Sci.	10	8.14
Physiol.—Chem.—Gen. Sci.	7	5.69
Physiol.—Chem.—Biol.—Gen. Sci.	6	4.87
Physiol.—Biology	5	4.06
Physiol.—Biol.—Gen. P.S.	5	4.06
Physiol—Chem.—Physics.	4	3.25
Physiology—Physics	3	2.44
Physiology—Gen. P.S.	2	1.625
Physiol.—Biol.—Physics	2	1.625
Physiol.—Biol.—Phys. Geog.	1	.814
Physiol.—Gen. Sci.—Physics	1	.814
Physiol.—Gen. Sci.—Astron.	1	.814
Physiol.—Floriculture—Horticultural Sci.*	1	.814
Physiol.—G.S.—G.P.S.—Biol.	1	.814
Physiol.—G.S.—Chem.—Physics	1	.814
Physiol. and 4 other sciences	5	4.06
Total	123	100

* One semester.

TABLE XII

COMBINATIONS OF GENERAL PHYSICAL SCIENCE WITH OTHER HIGH SCHOOL SCIENCE COURSE

Combination	No.	Per cent
Gen. Phys. Sci. only	2	10.53
G.P.S.—Biol.—Physiology	5	26.37
G.P.S.—Biology	2	10.53
G.P.S.—Physiology	2	10.53
G.P.S.—Gen. Sci.—Biol.	1	5.26
G.P.S.—Gen. Sci.—Biol.—Chem.	1	5.26
G.P.S.—Biol.—Chem.—Physics	1	5.26
G.P.S.—Gen. Sci.—Biol.—Physiology	1	5.26
G.P.S. — Gen. Sci. — Chem. — Physics	1	5.26
G.P.S. and 4 other sciences	2	10.53
G.P.S.—Gen. Sci.	1	5.26
Total	19	100

or 15.98 per cent of the 288 having had chemistry. No discussion seems necessary of the data in these tables.

Table XIII was constructed in order to easily study the frequency of the combinations of the six common science subjects among the 506 cases reporting.

It should be noted that the sum of the cases does not add up to 506 nor the percentages to 100 per cent because of duplication in the listings. This is also true of Table XIV.

In Table XIII each combination is considered under three headings: (a) the combination of two courses, (b) the combination of two with any other sciences, and (c) the total number with the combination. To illustrate: biology and chemistry were the sciences taken by 33 or 6.52 per cent of the 506 students. Seventy-five others or 14.82 per cent of the 506 took biology, chemistry, and one or more other sciences. This made a total of 108 students or 21.34 per cent of the 506 students who had the combination of biology and chemistry which was the most frequent combination. The chemistry-physics combination was practically as frequent as the biology-chemistry one with 107 or 21.13 per cent of the students; however, 46 or 9.09 per cent had just chemistry and physics compared with 6.52 per cent having just biology and chemistry. Third in frequency was the chemistry-general science combination with 104

TABLE XIII

FREQUENCY OF COMMON COMBINATIONS OF TWO HIGH SCHOOL COURSES

Combinations	No.	Per cent of Total
Biology—Chemistry	33	6.52
Biol.—Chem.—other science	75	14.82
Total with Biol.—Chem.	108	21.34
Biol.—General Science	24	4.74
Biol.—Gen. Sci.—other science	67	13.24
Total with Biol.—Gen. Sci.	91	17.98
Biol.—Gen. Phys. Sci.	2	.395
Biol.—G.P.S.—other science	11	2.17
Total with Biol.—G.P.S.	13	2.57
Biol.—Physics	8	1.58
Biol.—Physics—other sciences	42	8.30
Total with Biol.—Physics	50	9.88
Biol.—Physiology	5	.988
Biol.—Physiol.—other science	39	7.71
Total with Biol.—Physiol.	44	8.70
Chem.—Gen. Sci.	24	4.74
Chem.—G.S.—other science	80	15.81
Total with Chem.—G.S.	104	20.55
Chem.—Gen. Phys. Sci.	0	
Chem.—G.P.S.—other science	4	.790
Total with Chem.—G.P.S.	4	.790
Chemistry—Physics	46	9.09
Chem.—Physics—other science	61	12.05
Total with Chem.—Physics	107	21.14
Chem.—Physiology	14	2.766
Chem.—Physiol.—other science	32	6.324
Total with Chem.—Physiol.	46	9.09
Gen. Sci.—Gen. Phys. Sci.	1	.198
G.S.—G.P.S.—other science	6	1.186
Total with G.S.—G.P.S.	7	1.384
Gen. Sci.—Physics	4	.790
G.S.—Physics—other science	53	10.47
Total with G.S.—Physics	57	11.26
Gen. Sci.—Physiology	17	3.358
G.S.—Physiol.—other science	31	6.12
Total with G.S.—Physiol.	48	9.478
Gen. Phys. Sci.—Physics	0	
G.P.S.—Physics—other science	3	.593
Total with G.P.S.—Physics	3	.593
Gen. Phys. Sci.—Physiol.	2	.395
G.P.S.—Physiol.—other science	8	1.58
Total with G.P.S.—Physiol.	10	1.98
Physics—Physiology	3	.593
Physics—Physiol.—other science	12	2.370
Total with Physics—Physiol.	15	2.963
Total Cases Studied	506	

or 20.55 per cent of the 506 reporting the two courses. Other frequent combinations were biology-general science with 91 or 17.98 per cent, general science-physics with 57 or 11.26 per cent, biology-physics with 50 or 9.88 per cent, general science-physiology 48 or 9.48 per cent, chemistry-physiology 46 or 9.09 per cent, and biology-physiology 44 or 8.69 per cent.

Although the data on general science are possibly inaccurate as mentioned before, it is interesting to see which second course was taken by those having had general science who took one more high school science course. This assumed that general science was taken first which should be a safe assumption. On this basis the following can be observed from data for 506 total cases or 190 taking general science.

One course following ninth grade general science:

Biology 24 students or 4.74 per cent of 506 or 12.63 per cent of 190.

Chemistry 24 students or 4.75 per cent of 506 or 12.63 per cent of 190.

Physiology 17 students or 3.36 per cent of 506 or 8.95 per cent of 190.

Physics 4 students or 0.79 per cent of 506 or 2.11 per cent of 190.

General Physical Science 1 student or 0.20 per cent of 506 or 0.53 per cent of 190.

A similar analysis of the students taking general physical science plus one more course shows that 2 students or 0.40 per cent of the 506 cases or 10.53 per cent of the 19 taking G.P.S. selected biology as their second course. The same number selected physiology. None selected chemistry or physics. It must be noted that many students having general science or general physical science took more than one more science course.

Do these data indicate that the biological sciences and chemistry are presented in a more interesting manner in general science courses than is physics or is the difficulty with the mathematics of physics the reason for its low frequency? The data regarding general physical science are interesting in that no physical science course was the second course taken, all the second courses following general physical science were in the biological sciences. The number of general physical science students was too low (19) in this study to be of statistical validity; however, a study of general physical science as a feeder for chemistry or physics would be of interest. Possibly the general physical science offerings are designed for terminal work in the physical sciences rather than exploratory courses leading to further work in this area.

The chief objective of the study was to add to our knowledge of the science experiences of our college non-science curricular students in order to assist us in the planning of the basic science work that was needed to round out their science experiences. Therefore, the data were studied from the viewpoint of deficiencies in the high school science experiences of the 506

TABLE XIV

DEFICIENCIES IN HIGH SCHOOL SCIENCE EXPERIENCE

Areas	No. Stud.	Per cent of Total Cases	Total No. in Gen. Cour.	Per cent of Total No. in Gen. Cour.
Total students	506			
No Biology exp. (no G.S., Biol., or Physiol.)	116	22.92		
Slight Biol. exp. (had G.S., but no Biol. or Physiol.)	71	14.03	190*	37.37
No Chem. exp. (no G.S. or G.P.S. or Chem.)	106	20.95		
Slight Chem. exp. (had G.S. or G.P.S. but not Chem.)	97	19.17	209**	46.41
No Physics exp. (no G.S., G.P.S. or Physics)	203	40.12		
Slight Physics exp. (had G.S. or G.P.S. but not Physics)	144	28.46	209**	68.90
No Phys. Sci.. exp. (no G.S., G.P.S., Chem. or Physics)	84	16.60		
Slight Phys. Sci. exp. (had G.S. or G.P.S., but no Chem. or Physics)	80	15.81	209**	38.28

* Number of students having General Science and therefore some Biology experience.

** Number of students having General Science or General Physical Science and therefore some Chemistry, Physics, or Physical Science experience.

students. The headings biology, chemistry, physics, and physical science were established and studied from the two categories: no experience and slight experience. Slight experience was interpreted as the experience gained in a general course such as general science for all science subjects and general physical science for chemistry and physics.

The results are in Table XIV.

Deficiency in biological courses:

One hundred sixteen students or 22.92 per cent of the 506 reporting had no biology experience, neither general science, biology nor physiology; 71 or 14.03 per cent of the 506 had the biology experience from general science, but no biology or physiology course. The other columns in the table include the 190 students who reported general science and the fact that the 71 students having general science, but no other biology comprised 37.37 per cent of the 190 general science students.

A total of 187 or 36.96 per cent of the 506 cases studied had either no biology, physiology, or general science or only the biology obtained in general science. In other words, 37.0 per cent of the students had slight or no high school biology studies.

Deficiency in chemistry:

One hundred six or 20.95 per cent of the 506 cases had no general science or general physical science or chemistry. Ninety-seven or 19.17 per cent had general science, or general physical science but no chemistry so that they could be classed as having slight high school chemistry experiences. The total having no or slight chemistry experience was 203 or 40.12 per cent of the total cases. The 209 in the column in the table is the sum of the students having general science and general physical science of which the 97 students represent 46.41 per cent.

Deficiency in physics:

The total with no physics or slight physics experience in high school was 347 students or 68.58 per cent of the 506 cases studied:

Deficiency in physical science:

The total with no physical science or slight physical science (general science or general physical science) was 164 or 32.41 per cent of the total cases.

SUMMARY

1. The purpose of the study was to add to the information about high school science experiences of non-science curricula students at San Francisco State College in order to plan a revision of the basic science courses required for graduation of all students.

2. Five hundred six students listed the science courses taken during their ninth, tenth, eleventh, and twelfth grades in school. The data obtained were tabulated in various ways.

3. The courses most frequently reported were chemistry (56.9 per cent), biology (44.8 per cent), general science (37.5 per cent), physics (28.8 per cent), physiology (24.3 per cent), and general physical science (3.75 per cent). Sixteen other courses were reported by the group. (Table I.)

4. The highest percentage of the group had two courses (37.7 per cent), 30.0 per cent had one course, 22.7 per cent had three courses, 5.5 per cent four, 2.6 per cent had no science courses, while 1.2 per cent reported five, and 0.2 per cent six courses. (Table II.)

5. Of the 152 students having one course, 36.2 per cent had chemistry, 30.2 per cent biology, 17.1 per cent physiology, 7.9 per cent general science, 5.3 per cent physics, while four other courses were listed by a few students. (Table III.)

6. Of the 191 students with two high school science courses 24.1 per cent had chemistry and physics, 17.3 per cent chemistry and biology, 12.6 per cent chemistry and general science, 12.6 per cent general science and biology, 8.9 per cent general science and physiology, 7.3 per cent chemistry and physiology, while thirteen other pairs of courses were reported by fewer students. (Table IV.)

7. Of the 115 students having had three courses 19.1 per cent had biology-chem-

istry-general science, 19.1 per cent had general science-chemistry-physics, 12.2 per cent biology-chemistry-physics, 9.6 per cent biology-chemistry-physiology, 8.7 per cent biology-general science-physiology, 7.0 per cent biology-general science-physics, and fourteen other groups of three courses were reported by a few of the group. (Table V.)

8. Of the 35 cases with more than three science courses, 37.1 per cent had biology-general science-chemistry-physics, and 17.1 per cent had biology-general science-chemistry-physiology. A different combination was reported by each of the sixteen remaining cases. (Table VI.)

9. Combinations of chemistry with other sciences were tabulated in Table VII. Of the 288 students reporting chemistry, 19.1 per cent had only chemistry, 16.0 per cent had chemistry and physics, 11.5 per cent chemistry and biology, 8.3 per cent had chemistry and general science, 4.9 per cent chemistry and physiology, while the rest had combinations with two or more other sciences or with an unusual high school science.

10. Table VIII contains data on biology combinations. Of the 227 cases reporting biology, 20.3 per cent had it as their only science, 14.5 per cent combined with chemistry, 10.6 per cent with general science, 9.7 per cent with general science and chemistry, 3.5 per cent with physics, 2.2 per cent with physiology, while the remainder listed biology in combination with more than one other science.

11. General science combinations are listed in Table IX, 190 students reported this subject. Of these 6.3 per cent had it alone, 12.6 per cent each with biology and with chemistry, 11.6 per cent each with the biology-chemistry and chemistry-physics combination, 9.0 per cent with physiology, 2.1 per cent with physics, and the remainder with a number of sciences.

12. One hundred forty-six cases reported physics, 5.5 per cent alone, 31.5 per cent with chemistry, 15.1 per cent with general science and chemistry, 9.6 per cent with chemistry and biology, 8.9 per cent with chemistry, biology, and general science, 5.5 per cent with biology, 5.5 per cent with biology and general science while the remainder listed some 15 other combinations. (Table X.)

13. The reports on physiology combinations from 123 cases gave 21.1 per cent having it alone, 13.8 per cent combined with general science, 11.4 per cent with chemistry, 8.9 per cent with biology and chemistry, 8.1 per cent with biology and general science, 5.7 per cent with chemistry and general science. The rest of the group was distributed among fourteen other combinations. (Table XI).

14. Only 19 students reported general physical science courses. Of these 10.5 per cent had it alone, 26.4 per cent combined with biology and physiology, 10.5 per cent with biology, 10.5 per cent with physiology, while the eight remaining listed seven different combinations. (Table XII.)

15. An analysis of the frequency of two sciences in a student's experience is summarized in Table XIII. 21.3 per cent of the 506 cases had biology and chemistry in their high school science experience, 21.1 per cent had chemistry and physics, 20.6 per cent had chemistry and general science, 18.0 per cent had biology and general science, 11.3 per cent had general science and physics, 9.9 per cent biology and physics, 9.5 per cent general science and physiology, 9.1 per cent chemistry and physiology, 8.7 per cent biology and physiology, and the remainder had other combinations as listed in Table XIII.

16. The main purpose of the study was to discover the areas of science that were lacking in the non-science curricula college students. Therefore, the negative approach of "what deficiencies are there in science areas" was applied to the data and the findings summarized in Table XIV. A summary follows:

No biology experience.....	22.9%	of 506 cases
No physical science experience	16.6%	
No chemistry experience....	21.0%	
No physics experience.....	40.1%	
None or only slight biology study	37.0%	

None or only slight physical science study 32.4%
None or only slight chemistry study 40.1%
None or only slight physics study 68.6%

The data from this study indicate that studies in the two broad areas of biological science and physical science have been omitted from approximately a third of the college students reporting. Therefore, in any college program designed to round out the total experience of the students, it is necessary to include both science areas. The biological science is slightly more needed than the physical science, if there is any significant difference. Experiences with the materials from physics are much more needed than those pertaining to chemistry. In addition, information concerning the changing earth and its place in the universe must be included since approximately 58 per cent of the students in the study had no course that would include these ideas during the four years of schooling prior to entering college. (See Table I.)

GENERAL EDUCATION IN RELATION TO PREMEDICAL EDUCATION *

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MEDICAL educators and those preparing the young people of our country for medical schools are gradually becoming convinced that much of the present undergraduate training represents poor preparation for the study of medicine because it tends to overemphasize the natural sciences at the expense of the humanities and the social studies. Thus the prospective physician may be denied a knowledge of certain facts and concepts which are innately related to everyday experience in a democratic society. This type of knowledge is found in those phases of non-specialized and non-vocationalized learning which should be the common experience of all educated men and women and should lead to deliberative action for the fuller realization of democracy in every phase of living.

The objectives of general education commonly accepted by educators call for the inculcation of a common set of ideals and a common outlook on life based on our Western heritage.[1, 2, 3, 4] A code of behavior consistent with democratic ideals and with the necessary adjustment between the values of individual freedom and the demands of society must be erected on this common heritage. Accepting the sacred character of the individual, and predicating a successful society on the cooperative efforts of a happy people, such an education must direct the thoughts of the young to the opportunities available for development of innate potentialities to the utmost.

Democracy demands an ever-expanding enrichment of standards of living brought about by wise administration of natural resources, and this is possible only when the individual gains a better understanding of science and its uses. But facility in the communication arts, and growth in the appreciation of the esthetic experiences and cultural treasures of other peoples is essential for the development of a proper understanding and sympathetic attitude toward

* Based on the author's project report for the Ed.D. degree, Teachers College, Columbia University, 1949.

[1] Report of the Harvard Committee, *General Education in a Free Society.* Cambridge: Harvard University Press, 1946.

[2] President's Commission on Higher Education. *Higher Education for American Democracy, Establishing the Goals,* p. 41. Washington, D.C.: United States Government Printing Office, 1947.

[3] American Council on Education. *Cooperation in General Education.* Washington, D. C., 1947.

[4] American Council of Education Studies. *A Design for General Education,* Series 1, No. 18, Vol. VIII. Washington, D. C.

the rights and the problems of all. Only in this way can world-wide peace and prosperity be established and maintained. All of these desirable objectives are contingent, however, upon the individual citizen making contributions to an adequate economy. The individual is most likely to do this when he is engaged in the type of labor which he enjoys; a vocation for which he has been properly prepared and counselled.

If this be our goal for the citizen, it is pertinent to inquire whether it is not also a goal for the physician. He needs the type of education which will develop in him a high degree of social consciousness, and

TABLE I

MEDICAL SCHOOL ENTRANCE REQUIREMENTS IN THE NATURAL SCIENCES

(Note: All credits in semester hours. R = recommended)

Institution		General Chem.	Organic Chem.	Physical Chem.	Quant. Anal.	Gen. Qual. Quant. Chem.	Quant. & Qual. Anal.	General Biol.	General Biol. or Botany and Zoology	Comp. Anatomy	Zool. and Comp. Anat.	Botany and Zoology	Biology or Zool.	Embryology	Zoology	Embry. Physiol. or Anat.	Zool. & Embryol.	General Physics	Adv. Physics
Cornell	24	6	6	..	..	..	..	6	..	..	..	..	..	..	..	..	..	6	..
Jefferson	24	4	4	..	..	..	..	..	..	..	..	8	..	..	..	..	..	8	..
New York U.	26	8	4	..	..	..	..	..	..	..	..	8	..	..	..	..	..	6	..
U. Virginia	27	7	..	..	..	..	8	4	..	4	..	..	..	..	..	..	..	4	..
U. Nebraska	28	8	4	..	..	..	..	8	..	..	..	..	..	..	..	..	..	8	..
Temple	28	8	4	..	..	..	..	..	..	..	..	8	..	..	..	..	..	8	..
N. Car. U.	28	12	..	..	..	..	..	8	..	..	..	..	..	..	..	..	..	8	..
N. Y. Med.	28	8	4	..	..	..	..	..	..	..	8	..	..	..	..	..	..	8	..
Columbia	28	8	4	..	..	..	..	8	..	..	..	..	..	..	..	..	..	8	..
Arkansas	28	8	4	..	..	..	..	..	..	..	..	8	..	..	..	..	..	8	..
Hahnemann	28	8	4	..	..	..	..	..	..	..	..	..	8	..	..	..	..	8	..
Maryland	28	8	4	R	..	..	..	8	..	..	R	..	..	R	..	..	..	8	..
Buffalo	28	8	4	..	..	..	..	..	8	..	..	..	..	..	..	..	..	8	..
St. Louis	28	8	4	..	..	..	..	8	..	..	..	..	..	..	..	..	..	8	..
Creighton	28	8	4	..	..	..	..	8	..	..	..	..	..	..	..	..	..	8	..
Loyola (Chi.)	28	8	4	..	..	..	..	8	..	..	..	..	..	..	..	..	..	8	..
Chicago	28	8	4	..	..	..	..	8	..	..	..	..	..	..	..	..	..	8	..
Michigan	30	8	6	..	..	..	..	..	..	..	..	8	..	..	..	R	..	8	..
Missouri	31	8	5	..	..	..	..	..	..	5	..	..	..	..	5	..	..	8	..
Syracuse	32	8	8	..	..	..	..	8	..	..	..	..	..	..	..	..	..	8	..
Wayne	32	8	4	..	..	..	..	8	..	..	..	..	..	..	..	..	4	8	..
Vermont	32	8	8	..	..	..	..	8	..	..	..	..	..	..	..	..	..	8	..
Marquette	32	8	4	..	4	..	..	..	..	..	..	..	..	..	8	..	..	8	..
Boston	32	8	8	..	..	..	..	8	..	..	..	..	..	..	..	..	..	8	..
Miss.	32	8	8	..	..	..	..	8	..	..	..	..	..	..	..	..	..	8	..
Iowa	32	8	4	..	..	..	..	8	..	..	..	..	..	..	4	..	..	8	..
Harvard	32	8	8	..	..	..	..	8	..	..	..	..	..	..	..	..	..	8	..
G. Wash.	32	8	8	..	..	..	..	..	8	..	..	..	..	..	..	..	..	8	..
Albany	32	8	4	..	4	..	..	..	8	..	..	..	..	..	..	..	..	8	..
Duke	32	8	8	..	..	..	..	..	8	..	..	..	..	..	..	..	..	8	..
Illinois	34	6	4	3	3	..	..	..	..	..	..	..	..	..	..	..	10	8	..
Oregon	35	8	6	..	2	..	..	..	..	..	..	..	6	..	..	4.5	..	9	..
Tufts	36	8	8	..	..	..	..	..	8	..	..	..	..	..	..	..	..	8	..
Yale	36	..	..	..	..	16	..	8	..	..	..	4	..	..	..	..	..	8	..
Cincinnati	35	..	6	..	..	10	..	8	..	..	..	..	..	..	..	..	3	8	..
Indiana	38	8	8	..	..	..	..	..	..	4	..	..	..	5	..	..	3	10	..
Pennsylvania	38	18	..	..	..	..	..	..	..	..	..	..	8	..	..	4	..	8	..
Colorado	39	9	9	3	..	..	..	..	..	3	..	..	..	..	6	..	..	9	..
Rochester	40	8	8	..	..	..	..	8	..	..	..	..	..	..	..	..	4	8	4
West. Res.	42	8	8	4	..	..	..	8	..	4	..	..	..	..	..	..	4	8	..

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a truly sympathetic understanding of personalities, so that he may successfully discharge his extra-scientific duties.[5, 6] General education can aid him to acquire these attributes. As there is insufficient time in the crowded medical school curriculum to allow for this type of educational experience, it must and can be offered in the undergraduate preparation.

Let us now examine the preparation required for entrance to medical schools, and how the requirements are provided for by the average American liberal-arts college. The latter institutions train the bulk of the young people entering medical schools.

REQUIREMENTS FOR ENTRANCE TO MEDICAL SCHOOL

In the medical schools of the United States, the entrance requirements appear to be influenced to a considerable degree by the recommendations of the various state license boards and the Advisory Board of the American Medical Association.[7] A study of 57 per cent of these institutions indicates considerable agreement as to the science requirements for entrance. These requirements amount to eight semester hours in "general physics", twelve to sixteen semester hours in "chemistry" and eight semester hours in "biology".[8] The greatest variation is found in the "biology" requirement, as is indicated by the data in Tables I and II. Although most of the medical schools ask for a minimum of three years undergraduate preparation, competition for the limited number of places available each year tends to favor the student who has had four years of undergraduate work.[9] As a matter of fact, the natural science requirement would not be excessive if the medical schools were in greater agreement as to the biological preparation required. In the existing situation the candidate tends to take *all* undergraduate science courses required by *any* medical school in an effort to improve his chances of being accepted.

A study of the suggested premedical program offered by 52 liberal-arts colleges indicates that about 53 per cent of the three year program and 47 per cent of the four year program is devoted to the natural sciences (see Table II). This does not include additional work in the natural sciences in the form of electives, which the majority of the premedical students normally choose. The inescapable conclusion follows that our American liberal-arts colleges are permitting, if not advocating an extremely high degree of undergraduate overspecialization, which becomes a matter of critical concern because the physician is completely dependent upon the undergraduate college for his non-scientific education. The findings of this study agree with other surveys conducted by educators in recent years.[10, 11, 12]

CRITICISM OF THE STATUS QUO

The most serious criticism of the existing undergraduate preparation of the physician is that it fails to provide a more properly balanced program of studies. In the past doctors have made more than a fair share of significant contributions to literature, the sciences, and even philosophy.[13, 14] Today, the status of the physi-

[5] W. M. Johnson, "Preparing the Medical Student for Family Practice," *Journal of the American Medical Association*, 137:107–108, May, 1948.

[6] G. A. Hill, "A Critique of the Objectives of Scientific Training," *Bios*, 16:141–143, October, 1946.

[7] "Medical Education," *Journal of the American Medical Association*, 138:27, September 4, 1948.

[8] S. Dorst, "The Premedical Program," *Scalpel*, 16:101–108, August, 1946.

[9] "Medical Education," *op. cit.*, 138:26.

[10] S. Dorst, "The Premedical Program," *Scalpel*, 16:103, August, 1946.

[11] J. C. Hinsey, "The Objectives of Scientific Training in Premedical Education," *Bios*, 16:132, October, 1945.

[12] K. W. Vaughn, "Performance on the 1947 Professional Aptitude Test," Graduate Record Office, 1947, as quoted in editorial, "Premedical Education," *Journal of the American Medical Association*, 138:77, September 4, 1948.

[13] Edwin Lehman, "Cultural Values in Medical Education," *Southern Medical Journal*, May, 1945 (Reprint from).

[14] H. A. Larrabee, "The Case for the Liberal Point of View: A Reply and a Criticism," *Bios*, 16:169, October, 1946.

TABLE II

NATURAL SCIENCE PREPARATION SUGGESTED BY LIBERAL ARTS COLLEGES FOR STUDENTS PLANNING TO ENTER MEDICAL SCHOOL

Total Hours (Nat. Sc.)	Institution	Biology	Chemistry	Physics	Years
34	Detroit	8	16	10	3
38	Loyola (Cal.)	10	20	8	4
40	Texas Christ.	12	20	8	3
40	Georgetown	16	16	8	4
40	Maryland	16	16	8	3
40	Louisiana	16	16	8	3
42	Duke	8	24	10	4
42	Miss. College	15	18	9	3
42	Roosevelt	13	19	10	3
44	Albion	16	17	11	3
44	Hendrix	16	20	8	4
45	Mich. State	12	21	12	3
45	LaVerne	11	26	8	4
46	De Pauw	16	20	10	4
47	Haverford	16	23	8	4
47	St. Johns (Minn.)	16	21	10	3
48	De Paul	18	20	10	3
48	Idaho	16	24	8	3
48	Miami	14	26	8	3
48	Nevada	16	24	8	3
48	S. Dakota	16	24	8	3
49	Alaska	23	16	10	4
50	Portland	18	24	8	4
50	Fisk	20	20	10	3
51	Illinois	17	24	10	3
52	New York U.	20	24	8	3
54	Hope	18	26	10	4
56	Lebanon	24	24	8	4
56	New Hampshire	24	24	8	4
56	Spring Hill	24	24	8	3
58	Loras	28	24	6	4
58	Maine	28	22	8	4
59	Missouri Valley	24	25	10	4
59	Kansas	29	19	11	4
60	Carroll	32	20	8	4
60	Ozarks	24	24	12	4
61	Arkansas	19	32	10	4
61	Kalamazoo	21	30	10	4
61	Alabama	18	30	12	3
62	Oregon	16	35	12	3
62	Purdue	32	22	8	4
64	St. Vincent (Pa.)	28	28	8	4
64	Davis Elkins	32	24	8	4
65	U. Georgia	20	30	15	3
65	Stetson	27	29	9	4
66	Arizona State	24	32	10	4
69	Monmouth	33	26	10	4
69	Juniata	29	32	8	4
70	St. Josephs (Pa.)	28	32	10	4
70	Scranton	32	30	8	4
72	Manchester	24	36	12	4
79	Florida South.	24	37	18	4
86	Miss. College	51	26	9	4

cian as a learned man in the broadest sense of the term may well be deteriorating.[15]

[15] J. E. Burchard, "The Humanities and the Social Sciences in a Technological Education," *Journal of General Education*, 2:171–173, April, 1948.

At the moment we have far too few medical schools to educate the many thousands seeking admission. This has created a powerful spirit of competition among premedical students. Students cling to the theory that medical school entrance officials

will tend to give preference to those presenting an undergraduate preparation heavily loaded with the natural sciences rather than those who present a more balanced program. The liberal-arts colleges themselves set up imposing premedical programs, evidently reacting to medical college requirements in much the same way that individual students do.

In addition, it is probable that the liberal-arts colleges have been influenced by the old psychology of the transfer of training. If transfer could be achieved more efficiently by stressing the natural sciences (since they bear more relationship to medical school courses) it seems quite logical to some that time spent on the humanities would be mostly wasted in preparing the student for the study of medicine. The pre-professional curriculum undoubtedly has been influenced by this philosophy to the extent that it has become a mosaic of highly differentiated and unrelated courses with an obvious vocational objective.[16] The findings of many research studies over the last thirty years indicate that the doctrine of specific training rested on inadequate evidence concerning the operations of the human mind.[17] But though basic theories of education have changed with the acquisition of new psychological information, the practices of the past have tended to be perpetuated. It seems apparent that the time is ripe for constructive changes.

RECOMMENDATIONS OF POLICY GROUPS WITH RESPECT TO GENERAL EDUCATION

Many educators are in agreement that the areas to be covered by a general education should be " . . . those subjects which embody the great truths of our human tradition, the accumulated knowledge, skills and wisdoms which are the inalienable heritage of every child".[18] Thus it is desirable that every student attending a liberal-arts college should enjoy this common educational experience to some degree. This can be assured by a prescribed core curriculum. Enrichment of this foundation would be accomplished by election of additional courses on the basis of individual needs and interests. Guidance, so indispensable to any purposeful type of education, presumably would serve as the deterrent to the evil of overspecialization.

The prescribed courses should include both content and discipline from broad fields, but should not degenerate into the older survey type which flitted about a vast area, leaving the student little of value.[19] The student should be given some chance to come to grips with important problems in the area. The aim should be constantly in focus, and the content drawn from several departments requires careful integration and synthesis.

The humanities, with their concern about man's consuming interest in man; the fears, motives, needs, and hopes of men of all times portrayed in the great novels, poems, plays, and essays of the past and the present; bring to the young person an understanding of his heritage, and insight into the emotions, drives, and aspirations of his fellow men. No single era of man's history has a monopoly on classical literature. Thus, courses of study designed to develop in the student an appreciation of the great thoughts of his fellow men must not be limited to the books of any particular age, but must embrace the past and the present.

Further development of facility in the use of the native tongue is fundamental for general education. The core curriculum insofar as communication is concerned, must allow for great variation, so that all may progress as rapidly as possible. It is the function of all instructors to demand that students read and speak English fluently.

The basis of human values and the rea-

[16] S. Hook, *Education for Modern Man*, p. xi, Introduction. New York: Dial Press, 1946.

[17] American Council on Education. *Cooperation in General Education*. A Final Report of the Executive Committee of the Cooperative Study in General Education, pp. 18–21. Washington, D. C., 1947.

[18] S. Hook, *Education for Modern Man*, p. 69.

[19] S. J. French, *The Need for a New Approach to Science Teaching*, Wiley, Bulletin, p. 1, December, 1947.

sonableness of an acceptable code of ethics must be investigated and carefully thought over by the young person who hopes to lead an active life in a democratic world. In the ideal situation, philosophy offers to the student the best thought and hypotheses formulated by the wise men of all times. The nature of causality, free will and truth are problems which enter into the thoughts of every thinking person. Man has proposed many solutions to such problems as the brotherhood of man, or an ordered universe, and hence there are many philosophies from which the student may choose.

The young people entering our colleges today will be called upon to help in the development of an atomic age democracy. The answers are not likely to be found in the history of the institutions of the past or even of the present day. The social studies must aid our youth by suggesting feasible social predictions, consistent with an era in which distances will cease to be a barrier separating different cultures. Advances in the physical sciences have forced mankind to consider world cooperation and control or face the possibility of devastating warfare. The courses in the social studies must not attribute an aura of fixed or eternal perfection to any man-made institutions as they exist today, but rather, examine their evolution and response to demands occasioned by the changing needs of all.

The role of the sciences in general education is to bring to the student realization that science should play as important a part in his personal life as it does in the world about him. The general principles which govern the physical environment should be known to all.[20] Science education must not strive for technical proficiency in itself, but for the eradication of prejudices, superstition, muddled thinking, and mental laziness. It should offer science experiences which will insure that those being educated will think accurately about the epoch-making scientific discoveries. Nor is it too much to hope that scientific education can bring to man a realization that international cooperation already achieved in the field of astronomy is possible in other fields.

The course in the physical sciences built around a core of physics, would nevertheless explore basic chemical concepts and celestial mechanics, but introduce only those functional facts necessary to an understanding of the fundamental problems. The science taught should not be a mere survey of countless and often unrelated facts, but a part of the total intellectual and historical process of man.[21]

The basic course in the biological sciences should truly be a study of life, and depart radically from the traditional college presentation in this irea. Emphasis both in lecture and in laboratory should be placed upon general concepts leading to an understanding of life functions in living organisms.[22] From there it should proceed to consideration of biological knowledge in relationship to human problems and welfare. The biological sciences can bring to the citizen a proper understanding and desire to use the natural resources of the nation for the benefit of all.

The method to be utilized in presenting sciences courses of this type involves wide use of laboratory facilities, lectures, demonstrations, conferences, field trips, and audio-visual aids. Students should be encouraged to engage in worthwhile projects, depending upon their range of interest. The only foreseeable restrictions upon the scope of subject matter would be limits set by the imagination of instructors and students.

RECOMMENDATIONS OF POLICY GROUPS WITH RESPECT TO PREMEDICAL EDUCATION

The plan of general education described is one advocated by various policy groups

[20] W. G. Leland, "Education for Freedom and Responsibility," *Bulletin of the American Association of University Professors*, 34:277, Summer, 1948.

[21] E. C. Kemble, "A General Education Course in Physical Science for Superior Students," *Journal of General Education*, 2:322–327, July, 1948.

[22] R. H. Woolworth, "Biology Is More Than Principles," *Journal of General Education*, 2:199–203, April, 1948.

for all types of students, and represents the foundations upon which a professional education (of necessity more specialized) should rest. Now let us turn to the recommendations of various medical educators as to premedical training, and note the degree of fundamental agreement with the proposals of the general education groups.

If the student is to receive the type of education which the various policy groups believe essential for the citizen practicing medicine, it seems probable that four years must be allotted to this work. Although the majority of the medical schools do not insist upon this, medical educators today have set up a minimum preparation of four years as essential to success in medical school.[23, 24, 25]

The student approaching the study of medicine should develop a keen sensitivity to the social problems of our technological culture, and especially the social aspects of medicine. Insensitivity on the part of the physician leads him to take a passive attitude toward poverty, malnutrition, prostitution, alcoholism, and crime, even though the very nature of his practice demands that he encounter such evils daily.[26] Preventive medicine can progress only as fast as the social consciousness of the physician advances. As Dublin and Allen[27, 28] have emphasized, the physician must understand the social and the physical setting in which people who may become his patients live. Lack of interest in racial problems on the part of the white physician has countenanced a shameful discrimination against the negro physician to develop in our American medical schools and societies.[29] Fundamental training in the social studies would do much to awaken in the American medical doctor a consciousness of the great damage being done by these evils to our nation's health and our international prestige.

The medical profession has had a long tradition of humane learning. The idea that a chasm must exist between humanistic and scientific interests is the recent product of overspecialization. Only by ranging freely in the wide world of thought through literature and art, science and mathematics, history and philosophy, can the physician build that foundation of mature wisdom, without which his latter technical cleverness may be but a menace to all concerned.

More frequently than most men, the physician is called upon to make responsible value judgments, which will have lasting effect upon his patients. In attempting to develop a more scientific type of medical practitioner, we may fail utterly to consider the physician as a human being and a counselor to fellow citizens, a need which must receive a high priority in any plan of premedical training.[30] The major job of the undergraduate institution should be to aid those preparing for medicine to develop the virtues of honesty, intelligence, memory, accuracy, application, intellectual curiosity, charity, faith, humility, hope and patience, rather than to attempt to preview

[23] D. B. Calvin, "Recent Advances in Medicine and Their Effect on Premedical Needs," *Journal of the Association of American Medical Colleges*, 22:82–89, March, 1947.

[24] C. V. Weller, "Essentials," *Journal of the Association of American Medical Colleges*, 16:90–92, March, 1941.

[25] C. F. Branch, "The Future of Medical Education," *Journal of the Association of American Medical Colleges*, 20:281–286, September, 1945.

[26] A. M. Lassek, "Social Aspects of Medicine," *Journal of the Association of American Medical Colleges*, 18:368–371, November, 1943. Also *Higher Education for American Democracy*, pp. 82–83.

[27] T. D. Dublin, "The Basis for Teaching Social and Environmental Factors in Medicine in the Undergraduate Medical Curriculum," *Journal of the Association of American Medical Colleges*, 22:142–148, May, 1947.

[28] T. Allen, "Availability of Education in the Negro Separate School," *Journal of Negro Education*, 264–65, Summer, 1947.

[29] The President's Commission on Civil Rights, *To Secure These Rights*, p. 73. New York: Simon and Shuster, 1947.

[30] F. Sternagel, "The General Practitioner and Community Leadership," *Journal of the American Medical Association*, 137:943–945, July, 1948.

in an ineffective fashion the scientific courses of the medical school.[31]

Johnson[32] has said that a doctor must be equipped with the tools of his trade, and must know his business from the immediate diagnostic procedure he employs to the basic foundations of that procedure, and be possessed of the scientific spirit of research. Hinsey and Whitfield[33, 34] believe that premedical training should present to the student the fundamentals of chemistry, physics, mathematics, and biology, and extensive experiences in the nature and use of the scientific method. This does not mean a highly specialized science course. There is no good reason why the premedical schedule should vary to any marked degree from that chosen by any other group of students in the liberal-arts colleges.[35, 36] Medical educators agree that any attempt to set up a list of the fundamentals to be taught in the premedical science course would be unwise, since there is no blueprint which will accurately portray the needs of every student. The future of medicine will best be served if students come into it with a variety of training.[37]

Meticulous training in observation, in precise recording by written or oral methods, in application of inductive and deductive reasoning, and in reaching well founded conclusions must be an important part of the undergraduate training. The success achieved in the use of the scientific method will, in final analysis, rest upon the degree of imagination and insight possessed by the student.

In a program of science teaching, the goal must be to make science as much a part of the life of the student as it is of the culture in which the physician will live.[38] The student must learn to apply the scientific method in his own life. This method is grounded on strict morality, since all of its operations must be of a sharable and not of an esoteric nature. Its unyielding demand for complete honesty and lack of bias is equalled only by its insistence upon accuracy and hard work. Science education which fails to bring about changes in the conduct of the individual is of slight benefit to civilization.[39]

In a word, there exists today very substantial agreement among the leaders of the general education movement and medical educators as to what constitutes a worthwhile preparation for medical school. It is the writer's impression that because of a lack of interchange of views, this remarkable degree of agreement is generally not appreciated by educators in the liberal-arts colleges. One encounters more statements by medical educators bitterly attacking the undergraduate overspecialization than similar statements by the proponents of general education. The medical deans are demanding that the liberal-arts colleges send them more truly educated men and fewer science technicians. Thus the *Journal of the American Medical Association*, in condemning the overspecialized type of premedical training, calls for more undergraduate work in history, literature, philosophy,

[31] W. C. Davison, "Qualities Which a Medical Student and Physician Should Have or Develop," *Journal of the Association of American Medical Colleges*, 16:278–281, September, 1941.

[32] V. Johnson, "Objectives in Premedical Education," *Scalpel*, 15:8–13, 1944.

[33] J. C. Hinsey, "The Objectives of Scientific Training in Premedical Education," *Bios*, 16:132–140, October, 1945.

[34] R. N. Whitfield, "Educational Indigestion," *Journal of the American Medical Association*, 137:110, May, 1948.

[35] D. Bailey Calvin, "The Humanities in Premedical Education," *Bios*, 16:180, October, 1945.

[36] F. C. Zapffe, "The Relationship Between General Education and Medical Education." *Thirty-eighth Yearbook of the National Society for the Study of Education*, Part II, p. 225. Bloomington, Illinois: Public School Publishing Co., 1939.

[37] J. C. Hinsey, *op. cit.*, p. 136.

[38] S. R. Powers, "Science and General Education," *Teachers College Record*, 49:373–381, March, 1948.

[39] J. R. Steelman, *Manpower for Research*. The President's Scientific Research Board. Washington, D. C.: United States Government Printing Office, 1947.

political science, economics and sociology.[40] A well-balanced program of general education can aid the premedical student to achieve the excellence in those disciplines desired by the medical college deans.

GUIDANCE AND SELECTION

Many of our premedical students know little of the practical life of the physician and the problems of modern medical practice. They know even less about the medical school curriculum. Unfortunately, this ignorance of the life for which they have indicated a preference is not theirs alone. Far too many of the liberal-arts instructors responsible for the preparation of these students share this deficiency. A well-planned four-year guidance program, employing competent counselors, frequent student meetings, guest speakers from the various medical fields, and excursions to hospitals and pharmaceutical laboratories will introduce more purposiveness into the premedical curriculum, and perhaps, make other students aware of the possibilities of the medical profession as a life work.[41-42] Developing a program of close liaison between the medical educators and those preparing the students for medical school will go far toward introducing more integration between the undergraduate school curriculum and that of the medical schools.[43] The liberal-arts college cannot provide the type of educated individual needed in the medical profession so long as it operates in a cloud of ignorance as to the type of premedical education the medical colleges seek.

It is the duty of the undergraduate school to dissuade those psychologically as well as intellectually unfit from pursuing a career in medicine. Far too many young people enter medical school with personalities not adaptable to the training, and fail to graduate.[44] A serious defect of the present guidance and selection program is its almost exclusive concern with intelligence, which after all is but one of the raw materials of the whole personality. By failure to appraise properly the temperament and emotional feeling which pervade the basic attitudes, a distorted picture of the individual is developed. While it is true that many of the devices which have been developed for the study of the personality are still in a crude state, in the hands of the competent psychologist these same devices can aid the college in its screening processes.[45] The danger of setting up unreliable stereotypes must be avoided.[46] Personality inventories and the Rorschach test offer rich possibilities for the detection of patterns of adjustment and maturity, anxiety and depression, compulsions, and eccentricities. In fairness to the student and the overcrowded medical schools every effort must be made to insure that only those truly suited for admission are encouraged to apply.

From a careful examination of the recently published reports of medical educators it seems quite clear that a pattern of premedical education incorporating intense specialization in the natural sciences is poor preparation for the life a successful physician must lead. The next question which arises is whether or not such a type of preparation is essential for success in medical school. Must a paradox develop in the training of the medical doctor? Must the student be denied the type of education he needs upon undertaking the practice of medicine, in order that he may successfully complete the medical school studies? Fortunately an excellent study deal-

[40] "Premedical Education," *Journal of the American Medical Association*, 138:77, September 5, 1948.

[41] Cyprian, J. Bro., "Personalized Faculty Counseling for College Students." *Proceedings of the Ninth Annual Conference of the Brothers of the Christian Schools*, 9:51–53, 1947.

[42] A. Gregg, "General Education in Preparation for Medicine," *Journal of General Education*, 11:91–95, January, 1948.

[43] H. G. Weiskotten, "Liaison Between Premedical and Medical Colleges," *Bios*, 16:215, October, 1945.

[44] T. G. Harding, "Evaluation of Subjective Characteristics of Premedical Students," *Scalpel*, 16:96–100, August, 1946.

[45] H. A. Carroll, *Mental Hygiene*, p. 268. New York: Prentice-Hall, 1948.

[46] G. Murphy, *Personality*, p. 654. New York: Harper and Brothers, 1947.

ing with this subject was carried out by McGrath [47] at the University of Buffalo Medical School over a period of eight years. The results indicated that some students who had taken many undergraduate science courses achieved high standing in medical school, but just as often students who took relatively few science courses did as well. Natural-science majors did not appear to have gained any great advantage over non-science majors. The evidence appeared to indicate that a student who presented a heavy concentration in any of the subject-matter fields should not for that reason be considered a superior candidate.

Another method of evaluating premedical education is already functioning. The *Medical College Admission Test,* sponsored by the Association of American Medical Colleges, was administered to 13,407 applicants in 1947–48.[48] All students applying to medical colleges belonging to the Association are now required to take this examination. The results are forwarded to member colleges, and are used by them as an additional criterion for determining an applicant's desirability. The Verbal Ability section of this examination is concerned with vocabulary and comprehension. It is designed primarily to measure mental abilities and aptitudes which are closely related to success in medical studies. Materials from scientific, social, and humanistic areas, together with quantitative ability, are evaluated. Knowledge of word meaning, ability to comprehend and interpret verbal materials in the three major areas, and ability to deal with quantitative concepts of a practical and abstract nature are involved. The achievement parts of the examination deal with "Understanding of Modern Society"; social problems in the fields of modern history, economics, political science, and sociology. "Premedical Science" covers broadly the understanding of the fundamental principles of biology, chemistry, and physics. Overspecialization in the natural sciences on the part of the student would be a definite hindrance rather than a help in achieving an acceptable score in this examination.

The writer believes that this examination in itself will prove a potent influence against overspecialization in the natural sciences. The examination represents a trend on the part of the medical schools toward a more liberal education in the undergraduate preparation.

[47] E. J. McGrath, "What Subjects Should the Premedical Student Study?" *Journal of the Association of American Medical Colleges,* 20:273–275, September, 1945.

[48] Educational Testing Service. *Medical College Admission Test,* pp. 1–9, Bulletin of Information, New Jersey, 1948–49.

PROPOSED PREMEDICAL SCIENCE CURRICULUM IN THE LIGHT OF THE GENERAL EDUCATION AIM, MEDICAL COLLEGE ENTRANCE REQUIREMENTS, AND POLICY GROUP RECOMMENDATIONS.

The preparation offered by the liberal-arts college must of necessity prove acceptable to the medical schools. A curriculum in science can be arranged which will implement the objectives of general education and also satisfy the science requirements for admission to three-fourths of the medical colleges. The Association of American Medical Colleges has proposed a minimum science preparation of 28 semester hours for medical school entrance. By adding four more semester hours in science (a total of 32), the present science requirements of 75 per cent of the medical colleges could be met. Twenty-five per cent of the curriculum would be in the field of science, but 12 of the semester hours involved would be in science courses designed for general education purposes, and only 20 semester hours would be in specialized science courses.

Under this curriculum arrangement a premedical student could major in areas other than the traditional biology or chemistry, and still be eligible for medical school admission. Spending fewer hours in the laboratory, he would have more time to engage in various college activities with his non-medical classmates. These changes

should go far toward the eradication of the traditional and harmful segregation of the premedical students.

The general education science courses. It is proposed that general courses in the biological and the physical sciences be offered, to be followed by certain more specialized science courses as indicated in Table III. Students preparing for medical schools would be required to take both of the general courses. Students planning to enter other vocations might be offered a choice, or might be required to take both, since they would be in the general education category. The course in the biological sciences would carry eight semester hours of credit, and would satisfy the present biology requirements for entrance to medical schools in the majority of cases. The course in physical sciences would carry four semester hours of credit, and would serve as an introduction to the more specialized courses in physics and chemistry needed by the premedical student.

TABLE III

THE SCIENCE CURRICULUM

Freshman	Sophomore	Junior	Senior
1st Sem.	3rd Sem.	5th Sem.	7th Sem.
Gen. Biology	Physical Sc.	Gen. Chem.	Gen. Physics
4 Hours	4 Hours	4 Hours	4 Hours
2nd Sem.	4th Sem.	6th Sem.	8th Sem.
Gen. Biology	Gen. Chem.	Organic Chem.	Gen. Physics
4 Hours	4 Hours	4 Hours	4 Hours

The course in the physical sciences organized on the basis of historical principles is similar to that evolved by Conant [49] at Harvard University. A "feel for science" is developed through intensive studies of case histories drawn from times when organized science was in its beginnings. This course, planned for one semester, would meet for three lectures and one additional hour of discussion per week. The case histories chosen emphasize the development of a conceptual scheme from experiment; the overthrow of earlier ideas; the importance of measurement, and the necessity for isolating and controlling a great number of variables. Every effort would be made to help the student place the development of these new ideas of science before the cultural background of the period of history involved.

Both the premedical student and those planning other careers have similar needs insofar as the biological sciences are concerned. Unfortunately many suffer from the misapprehension that the medical college courses are so highly technical that a specialized preparation in the biological sciences is required. The basic science courses offered in the first two years of medical school do not require any more searching preparation than that offered by the proposed course in "general biology". Those students whose interests might lead them to further study in the biological sciences would find this course sufficient introduction for more specialized work at the undergraduate level.

Emphasis in this course would be placed upon those facts, concepts and principles of life, whose understanding is essential if the student is to understand his relationships to the world of living things. Life and its functions would be the theme throughout with constant application to human affairs. Thus, the course would draw heavily from human physiology, and depart from the older taxonometric theme. The laboratory and the world outside the lecture hall would become the important centers of teaching. That the student would benefit more from a knowledge of the race than from the study

[49] Earl J. McGrath, *Science in General Education*, pp. 103–108. Dubuque, Iowa: W. C. Brown Co., 1948.

of the serial homologies of the Malacostraca seems indisputable today.[50]

The more specialized portion of the recommended science curriculum consists of courses in chemistry and physics involving 20 semester hours. Eight hours of these are in general physics. This course requirement of the medical schools is quite well standardized. The specialized courses in chemistry now commonly required are general chemistry and organic chemistry. General chemistry is usually given over a period of two semesters for a credit of eight hours. Organic chemistry consists of a brief survey of important classes of compounds in the aliphatic and aromatic series, and the important syntheses and reactions of various classes of organic compounds; to this is allotted four semester hours.

The major. The trend of the general education emphasis in colleges today is clearly described in the recent volume *Science in General Education.*[51] This study of the science curricula of a number of leading liberal-arts colleges indicates that about 40 per cent of the total curriculum is devoted to the new type of education. A clear trend is also discernible toward incorporating in the core curriculum training in both the biological and physical sciences. Integrated studies in the humanities and the social studies complete the prescribed portion of the curriculum.

The program of studies presented here would fit well into the general education program suggested by the contributors to this review. Twelve of the 48 semester hours assigned to general education would be devoted to the biological and the physical science courses. The remaining 36 semester hours would be apportioned to studies in the humanities and the social sciences.

The premedical student following such a program of education would be required to complete 68 semester hours of prescribed courses, 48 in general education and 20 in the specialized science courses. The remaining 52 hours would allow ample time and freedom for satisfying the needs of the individual student for further specialized training in the area of learning in which his interests lie. Thus the medical advisory committee could suggest work in a foreign language, mathematics, and additional experiences in the humanities and the social studies which they might feel necessary to adequately prepare the student for the life of the physician. The premedical student might elect to major in one of the natural sciences, but he would not be barred from majoring in one of the humanities or social studies.

Summary. This type of curriculum would bring to the student a wider acquaintance with non-science areas, and would tend to make him more conscious of his needs in those fields. If he is made to realize that the medical school curriculum will take care of his needs in the field of basic medical sciences, he is more likely to feel the desire to gain greater understanding of the social studies and humanities. He will also realize that this is probably his last chance to take advantage of such formal offerings.

To deny to the physician the benefits of general education on the pretense that science specialization at the undergraduate level is essential to success in medical school is to deprive our democracy of the social talents of one of our most intelligent groups of citizens. Today more than ever we need the wisdom of all of our citizens to aid in perfecting the democratic way of life.

[50] H. Federighi and C. Leuba, "The Proper Study of Mankind is Man," *Journal of General Education,* 2:193–198, April, 1948. T. S. Hall, "Implications of General Education for the Teaching of Biology," *Journal of General Education,* 2:107–116, January, 1948. A. Lawson, "Basic Biological Science at Michigan State College," *Journal of General Education,* 2:75–82, October, 1947.

[51] Earl J. McGrath, *Science in General Education.* Dubuque, Iowa: W. C. Brown Co., 1948.

INTRODUCING THE CONTRIBUTORS

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versity of Minnesota; Northern Montana State College (Havre); Hamline University and the Universities of Chicago, West Virginia, Missouri, and Illinois. He is well known by readers of *Science Education* because of his numerous research papers and as a former president of The National Association for Research in Science Teaching (1934–35).

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BOOK REVIEWS

REDDICK, HARRY W. *Differential Equations.* New York: John Wiley and Sons, Inc., 1949. 288 p. $3.00.

This is a clear discussion of the solution and practical applications of ordinary differential equations.

WEISS, MARIE J. *Higher Algebra for the Undergraduate.* New York: John Wiley and Sons, Inc., 1949. 165 p. $3.75.

This is a text designed for a six-semester hour course for a student who has had two years of college mathematics including calculus.

SYMPOSIUM. *Proceedings of the Eighty-Seventh Annual Meeting of the National Education Association held at Boston, Massachusetts, July 3–8, 1949.* Washington, D. C.: National Education Association, 1949. 419 p.

This is a summary of addresses before the Representative Assembly, minutes of business meetings, annual reports, reports of departments, and association records, and information.

SELSAM, MILLICENT E. *Play With Plants.* New York: William Morrow & Co., 1949. 63 p. $2.00.

Play With Plants is a Morrow Junior Book. It is a book of experiments with plants that both pupils and teachers will find enjoyable. Contents include: plants grow from roots, stems, and leaves; plants grow from seeds; how seeds grow; about experiments; plants need water; and plants need light. Nearly every page has a graphic picture that helps to explain the different experiments. The illustrations were drawn by James MacDonald. This is recommended as an excellent book for the elementary science book shelf.

C. M. P.

ASHFORD, MAHLON (Editor). *Trends in Medical Education.* New York: The Commonwealth Fund, 1949. 320 p. $3.00.

This is a symposium sponsored by The New York Academy of Medicine Institute on Medical Education. Six conferences conducted as round table or panel discussions were held. This is a report of each of these conferences which make up the six parts of this book: Premedical education and the selection of medical students, undergraduate medical education, the medical education of interns and residents, graduate and postgraduate training for specialization, the responsibility of medical schools and hospitals in the education of the general practitioner, and the relation of group practice and community medical services to medical education.

Secondary schools can do much by proper guidance to get the more desirable students to consider medicine as a profession.

Dr. Victor Johnson has set forth the following qualifications for a doctor: (1) he must be a good citizen, (2) he must be equipped with the tools of his trade and he must know his business from the immediate diagnostic procedure he employs to the basic foundation of that procedure, (3) he must possess the scientific spirit of research, and (4) he must possess a strong social consciousness.

ADAMS, ANSEL. *The Negative: Exposure and Development.* New York (101 Park Ave): Morgan and Lester, 1948. 120 p. $3.00.

The Negative has been written by Ansel Adams, one of America's foremost authorities in photography. It covers all phases of exposure and development. There are 21 informative diagrams and tables and 41 reproductions of the author's original photographs. In this book Ansel restates the classic principle of photograph: exposure for the shadows and develop for the highlights. Undoubtedly this is one of the best books on this particular phase of photography.